

AN ARGUS SPECIALIST PUBLICATION

# electronics today

INTERNATIONAL

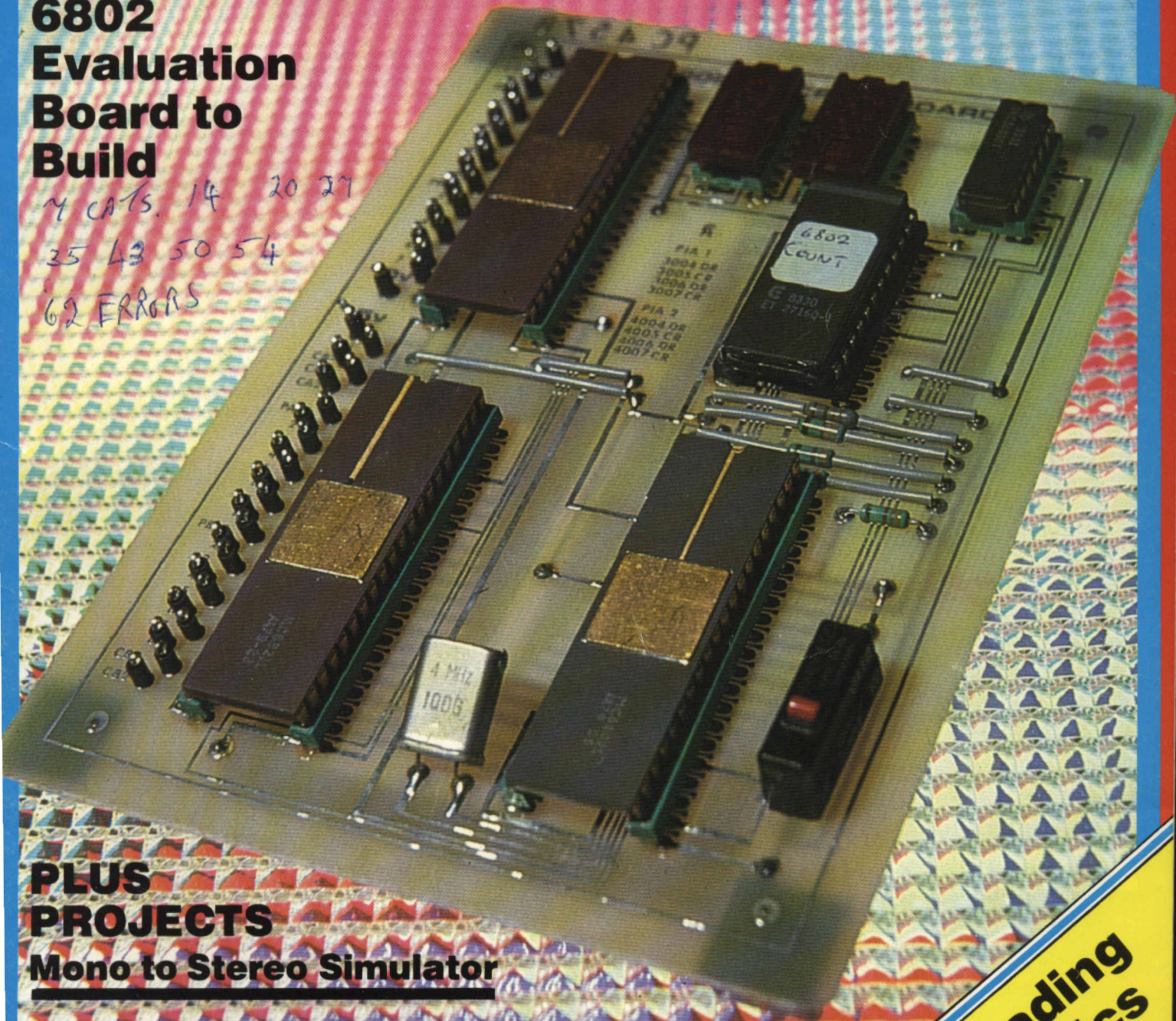
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## Break into code!

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35 43 50 54  
62 ERRORS



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Numerical Scoreboard Display

Universal EPROM Programmer MkII

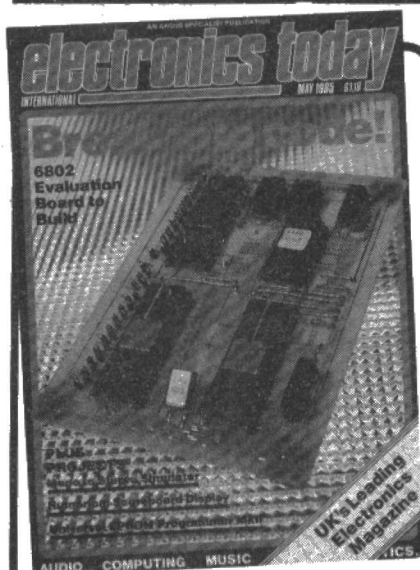
UK's Leading  
Electronics  
Magazine

AUDIO... COMPUTING... MUSIC



# electronics today

INTERNATIONAL MAY 1985 VOL 14 NO 5



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# DIGEST

## Call For Science Minister

Science needs a minister, say the Alliance for Science, a campaign set up by three trade unions who represent 100,000 scientists and technologists. They are also calling for a National Economic Develop-

ment Council (NEDC) to cover research and development, pinpointing crucial research areas to permit the most effective use of funds.

In a pamphlet entitled *The case for a research and develop-*

ment strategy, the group call on the government to co-ordinate such a strategy as suggested by the House of Lords Select Committee on science and technology. They argue that a science minister should head a cabinet committee to look at science funding and plot long term research and development objectives.

They call for more government funds to be pumped into research and development, particularly in areas such as information technology where we are said to be falling behind our competitors, and they believe that an NEDC is the best way of

ensuring that the money goes to where it is needed most.

The pamphlet is the second publication from the Alliance, which was launched in December of last year. The three unions involved are the Association of Scientific, Technical and Managerial Staffs (ASTMS), the Association of University Teachers (AUT) and the Institution of Professional Civil Servants.

For further information about the Alliance for Science contact Bill Brett of IPCS on 01-928 9951, Paul Cotterell of AUT on 01-221 4370, or Stan Davison of ASTMS on 01-267 4422.

## Handheld Logic Analyser

An ultra-compact logic analyser, which provides a full range of measurement facilities in a handheld, battery-operated format, has been introduced to the UK by House of Instruments.

The SOAR 1300 Series, available in 10MHz or 20MHz versions, use a high-contrast liquid-crystal dot-matrix display to provide comprehensive logic-timing, state and signature analysis on up to 16 channels, with features such as trigger position, trigger pass count and trigger delay included as standard. The 1"x3" display is mounted on the top and shows eight channels at a time.

The instrument measures 253 x 140 x 38mm and weighs only 1kg, making it ideal for field-service use. Power is provided by

four AA batteries or an optional AC mains adaptor, while key set-up parameters and acquisition data are retained for up to one year by an internal battery-backup memory function.

The 1300 Series may be used in single, repeat or compare acquisition modes, and data display, compare and search facilities are provided. Other display features include a x4 magnification, a window facility for examining part of a larger display, and a histogram display to compare the numbers of high- and low-level bits.

The instrument has built-in self-checking facilities, including battery-low indication, and an automatic power-off function to conserve battery life between readings.

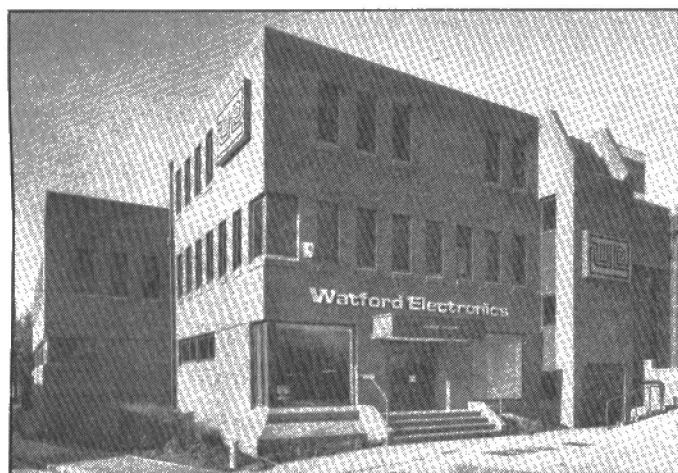
The price of the 10MHz model



(1310) was not available when we went to press, but the 20MHz version (1320) costs £1987.00 plus VAT. The instrument is also available in a form better suited to bench use, with the display on the front panel and a tilt stand. These models are designated

1410 (10MHz) and 1420 (20 MHz), and the 1420 costs £2146.00 plus VAT.

House of Instruments, Raynham Road, Bishops Stortford, Hertfordshire CM23 5PF, tel 0279-55155.



## Watford Moves

Watford Electronics, a company which started with one man working from his home, has just moved into new, purpose-built premises in Watford's High Street.

The company was founded twelve years ago by Nazir Jessa, an optician who spent his evenings and weekends selling components from a stock kept in the corner of his bedroom. Although he

advertised 'mail order only', Nazir spent his weekends serving the people who insisted on calling in person, and the queues often filled his lounge and hall and extended to the front gate and beyond.

Assisted by his younger Brother Raza, he build the company up until, after three years, he was able to buy the shop next door. Within a year the extra stock needed to serve the fast-expanding business filled even this space, and the problem has only been remedied with the move to the new building.

Called Jessa House, the premises house over 7000 different components and micro peripherals and cost £700,000 to build. Nowadays they actually welcome personal callers, and although they now have a staff of thirty Nazir and Raza still take their turn behind the counter.

Watford Electronics, 250 High Street, Watford, Hertfordshire WD1 2AN, tel 0923-37774.

● Electrovalue's spring '85 catalogue is now available and its 44 A5 pages list a wide range of components, tools, computer equipment, test gear and technical books. The catalogue can be obtained free of charge from Electrovalue Ltd, 28 St Judes Road, Englefield Green, Egham, Surrey TW20 0HB, tel 0784-33603.

● Cirkuit, the re-incarnation of component suppliers Ambit International, will be launching their spring catalogue on April 11th. It will be available from leading newsmagazines throughout the country for £1.15 and lists over 4000 components along with kits, tools and microcomputer peripherals. Cirkuit Holdings PLC, Park Lane, Broxbourne, Hertfordshire EN10 7NQ.

● We ran out of space this month, but we'll make sure we give the results of the Reader Survey Free Subscription offer next month.



## Events Diary

### Amateur Radio & Computer Fair - April 8th

Bretton Hall College, Wakefield, from 11.00am. Organised by North Wakefield Radio Club. Free Admission, various stalls, film shows, amateur radio talkin on 145.550MHz, beer and refreshments available. Contact S. Thompson, G4RCH, 2 Alden Close, Morley, Leeds LS27 0SG, tel 0532 - 536633.

### The Limits of Digital Audio - April 9th

The IEE, Savoy Place, London WC2 at 7.00pm with tea from 6.45pm. Lecture by Dr. Lagadec of Willi Studer AG organised by the Audio Engineering Society. Non AES members welcome to join-up on the evening.

### Motorola Power Design Seminar - April 15th

Sheraton Hotel, Heathrow. Programme includes SIDAC technology, switchmode 1,11 & 111, switchmode rectifiers and power MOSFETs and cost is £28.75. Contact Betty Fogg, IEL Travel Ltd, 9 Argyll Street, London W1V 2HA, tel 01- 734 8200.

### Innovation '85 - April 16-19th

Cranfield Institute of Technology, Cranfield, Bedford, from 10.00am to 5.30pm daily. IT exhibition sponsored by Rank Xerox and intended to provide a clear overview of the technology for those considering installations and for students and others planning careers. Innovation '85, Bridge House, Oxford Road, Uxbridge, Middlesex UB8 1HS, tel 0895 - 51133.

### Northern Computer Show - April 16-18th

Belle Vue, Manchester. Business and professional computer exhibition aimed at both established and first time users. Contact the Exhibition Manager, The Northern Computer Show, Reed Exhibitions, Surrey House, 1 Throwley way, Sutton, Surrey SM1 4QQ, tel 01-643 8040.

### Computer Aided Design & Engineering in the Aircraft Manufacturing Industry - April 17th

Institution of Mechanical Engineers at 6.00pm. Lecture by H. Hitch of British Aerospace Aircraft Group. Contact Peter J. Pugh, Engineering Manufacturing Forum, I. Mech. E., 1 Birdcage Walk, London SW1H 9JJ, tel 01- 222 7899.

### Hospital Broadcasting Conference - April 19-21st

Newport, Gwent. Residential weekend including training sessions, equipment exhibitions, seminars and debates organised by the National Association of Hospital Broadcasting Organisations. Non-members are welcome and the cost is £51.00 including full board. Contact Alf Partridge, Conference Chairman, NAHBO, c/o 56 Fleet Road, Benfleet, Essex SS7 5JN.

### Scottish Design Engineering Show - April 23-25th

Anderston Exhibition Centre, Albany Hotel & Holiday Inn, Glasgow. Exhibition of new design engineering ideas aimed at engineers and managers. Contact Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham, Middlesex TW1 3SZ, tel 01-891 5051.

### Portable Computing Conference - April 25/26th

Fulcrum Centre, Slough. Conference and exhibition aimed at enabling management staff to assess the value and implications of portable computing techniques and including products from fifty or more leading suppliers. Costs from £109.25 for a half-day to £281.75 for two days. Contact the National Computing Centre, Oxford Road, Manchester M1 7ED, tel 061- 228 668962

### The British Electronics Week - April 30th to May 2nd

Olympia, London, 10.00am to 6.00pm daily. The exhibition brings together the All Electronics/ECIF Show, Fibre Optics and Electronic Product Design, and the organisers claim that virtually every electronics company will be represented. Free entry by ticket obtained in advance from Evan Steadman Services Ltd, The Hub, Emson Close, Saffron Walden, Essex, CB10 1HL, tel 0799 26699.

### Electronic Production Efficiency Exposition - April 30th to May 2nd

NEC, Birmingham. See February issue for details or phone 0280 - 815226.

## Framestores Make The World Go Round

**T**hose of you who manage to stay awake in front of the television may have noticed a change recently in the style of the BBC 1 rotating globe symbol. The old mechanical model with its electric motor and fixed camera has gone, to be replaced by an all-electronic system using framestores.

The BBC's graphic designers came up with a new image of the world, with improved accuracy and detail. The symbol achieves a full three-dimensional effect using solid continents and islands mapped onto a transparent sphere, which is enhanced by colour shading and highlighting. The hardware for displaying the symbol was developed by Engineering Designs and the animation was produced by the staff of the BBC Computer Graphics Workshop. The original map database of 20,000 points was provided by Glasgow University.

The full rotation of the world takes 12 seconds which is equivalent to 600 television fields. To store this digitally would normally take some 250 Mbytes of memory, but a data-saving technique has been invented (patent applied for) which stores a single field of the world

in only 8 Kbytes. Each map is imprinted upon the foreground (the highlighted gold) and the background (the shaded blue). For each TV field a map is read from memory in sequence so that the world appears to rotate.

The hardware uses two 800 Kbyte full-resolution framestores to reproduce the blue and gold areas of the symbol and the captions. This data is stored as eight-bit samples in accordance with the internationally agreed coding standard (CCIR Rec. 601). The compressed map data is stored in a separate memory of more than 4.5 Mbytes. Erasable 28 Kbyte memories are used for all data storage, and high-speed digital techniques are employed throughout.

Fourteen such equipments have been installed in the BBC's main and Regional centres, each with their own caption identification. The London equipment optionally displays a caption indicating the page number for programmes subtitled on Ceefax.

Engineering Information Department, BBC, Broadcasting House, London W1A 1AA, tel: 01-927 5432.

## ETI Takes Allsorts

**O**ne of the advantages of working on a magazine is that you get some very interesting things through the post. Advertising agencies keen to catch your eye send out all manner of promotional novelties, and there is scarcely a desk in the company which does not groan under the weight of pens, ashtrays, diaries and 'executive' toys, each emblazoned with the name of some electronics company or other.

Occasionally some go a little further, and not a few desks still bear the lens-less spectacles, sparklers and mounted lump of coal which mark some of the more notable recent advertising campaigns.

But no-one ever bothered to send us anything to eat. Presumably, writers on food magazines spend their entire working lives chomping through the edible offerings from each morning's post bag, but not so

electronics writers.

Until now, that is. Possibly labouring under the impression that ETI stood for Eating Today International, Only Natural Products Ltd, part of the Bassett foods company, recently sent us a packet of their new Traditional Recipe Liquorice.

The accompanying press release waxed lyrical about mixtures of liquorice and aniseed and the marriage of traditional techniques with modern production methods which went into producing this fine product, and indeed, the liquorice does taste pretty good as the Assistant Editor can well testify. But none of this explains why they sent a sample to us.

Still, who's complaining. The Assistant Editor is now considering the idea of starting a regular food column in the hope of attracting more such samples, and wishes it to be known that, if Bassetts are planning any further promotional activity, he'd prefer it if they sent him some Liquorice Allsorts next. Please?

(P.S. Or some Fudge? Ed.) **ETI**



# READ/WRITE

## To Boldly Go...

Dear Sir,

The article about Electronics for Peace in the April Issue of ETI shows clearly how Electronics Technicians can get themselves a bad name for political naivete. The organisers of this movement should know that including the word "Peace" in the title of any organisation means that it will be regarded as a front for Communist activity. If one then goes on to publish secret information on weapons systems, suspicions are heightened whatever the organisers may say. You may rest assured that anyone foolish enough to join such a movement will be certain to have their phone tapped! In due course they may also be invited to a Worker's Congress in Prague, the bourne whence no worthwhile technician ever returns.

This is not to say that a truly independent political organisation for technicians is not needed, indeed it is vitally necessary. But it should be organised under the banner of FREEDOM, something which is anaethema(sic) alike to Communist and Capitalist systems. (Electronics for Freedom -EfF)?

In every society of the world the Technician suffers exploitation by immature and often incompetent megalomaniacs. Technicians as a class are rather meek, but if we are to inherit the earth we have to find a better way to make the consensus (sic) of our views publicly known. We have to assist in creating a just society, make communication between peoples easier and use our skills to expand the capabilities of the mind. Electronics is vital in all this, so the objectives of the organisation would be as follows:

1. Making possible secret mass referenda on all important political issues by electronic means using TV, radio or telephone.

2. Development of Computer Systems, Languages and Programmes to formulate just and unambiguous legislation, regulations and codes of practice.

3. Development of personalised communication systems with miniaturised privacy devices (scramblers), and computerised translation facilities.

4. Development of bioelectronic devices and biofeedback methods for mind control and expansion. Also to enable the assessment and evaluation of personality types.

The last objective is the final frontier of electronics - understanding the nature of the mind and discovering who are fit persons to be trusted with power. These activities are far more worthwhile than merely ferreting out details of obsolescent weapons systems for the benefit of the RIS.

Anyone who feels they would like to form an organisation on these lines can get in touch with me at the University of Surrey where I work.

Yours faithfully,  
Keith Wakeham  
Church Crookham  
Hampshire

Nice try, Mr. Wakeham, but you can't fool us. 'The final frontier', all that stuff about 'Computer Systems', 'personalised communication systems' and expanding 'the capabilities of the mind'. Beam us up Scottie, if you're not Mr. Spock. By the way, we gather Captain Kirk's been looking for you.

## Bass From The Wood

Dear Sir,

I have scanned 'The Final Link' by Vivian Capel (ETI April 1985) with interest. It was surprising for me that no mention was made of studio and concert hall acoustics. There were two programmes recently on Radio 3, concerning concert hall 'design' and the reactions of performers and listeners. Even in these programmes, I felt that the experts have somehow got several matters wrong.

It is well known that the Festival Hall and the Barbican are unsatisfactory - due, it is said, to the air-conditioning ducts under the seats absorbing most of the deep bass.

No mention was made of Bayreuth or Covent Garden, and it was implied that hard walls (brick or stone) were good. My experience is that the bass from Bayreuth is very good, the walls being, I believe, of wood.

A visit to Covent Garden immediately exposes the good bass, but on my equipment the bass from there is rather weak. I wonder if this is because suspended microphones tend to 'blow away' from the deep bass?

A recent broadcast from a cathedral in Wales sounded very bad indeed (stone wall etc). It was a Mozart string orchestra, and even a moderate volume setting was too high. The only solution was to turn the volume very low.

If the bass of the hall is good, volume can be turned surprisingly high, with every pleasure, to my ears. Some Wagner records come through very well.

A particularly irritating habit of the BBC is to broadcast a concert at reasonable volume level; then on return to the studio the voice is often too loud, even painful, so the volume has to be turned down. This could be due to a combination of poor studio acoustics, poor monitor speakers and insensitive control engineers.

I also find that only tape at 7 1/2 ips gives really good HiFi. Discs are not bad with the Goldring Epic cartridge (only £15) but here again volume has to be kept fairly low, to avoid listener fatigue and discomfort. Here again I suggest it is the deep bass which goes wonky. Of course, commercial discs do not give much in the way of really deep bass. I find that some popular discs have quite good bass almost regardless of the size and make of the speakers. I'd guess these attractive results are given by microphones on rigid heavy stands set close to the bass instruments.

I use a Quad 303 amplifier and my speakers are approximately 10 cubic feet each made of brick and stone. Upper register is via Trelex and Olidax horns (sic), attenuated



to suit 12" woofers set in the enclosures.

There are some listening room effects - it is a longish room with plastic/concrete floor.

I hope these remarks could lead to further work along the lines of Mr. Capel's article.

Yours sincerely,  
John Elliott MSc  
Farnborough  
Hants.

Personally, we listen to most of our music in the bath and we sometimes wonder if the lack of fidelity isn't due to the water in our ears.

## Film Facts

Dear Sir,

I read with interest Mr. Armstrong's feature on 'telecine' and whilst agreeing with almost all within there are several points of accuracy that I would contest.

1. The aspect ratio between the cinema and television is not necessarily different. The 1.33 to 1 (4 to 3) aspect ratio used by most TV stations throughout the world is in fact Motion Picture Academy Ratio. Almost all films pre-1950, many films of the 50's and 60's and all film series made for television are to this ratio. In the early years of television round display tubes were used and 5:4 would have been displayed with better efficiency; despite this 4:3 for television was chosen so as to be compatible with the cinema.

2. The frame of Cinemascope film is not the same size as an ordinary 35mm film. A standard Academy frame is .625" high, there are quite broad 'rack lines' between frames. The frame height of Cinemascope is .715" and the rack lines are very narrow (35 thou.)

3. A true Cinemascope, that is 20th Century Fox, film will have 4 track magnetic sound; to accommodate this and not encroach on the picture area the sprocket holes on the film are smaller, the pitch is the same, however.

4. In the sequence of operations for a projection system at step

two it is said that a claw engaging with the holes in the film moves the frame into position. Although 35mm cameras may use claws, 35mm projectors do not. The usual practise is to use an intermittent sprocket driven by a Maltese Cross mechanism.

5. Although it is common practice to refer to all anamorphic formats as Cinemascope this is rather akin to calling all vacuum cleaners Hoovers. Cinemascope was in fact a trade name of an anamorphic system used by 20th Century Fox. This system has now not been used for some years; most anamorphic films now are shot to the Panavision standard on their equipment.

Yours faithfully,  
Nick Lyons  
Normanton  
West Yorkshire

## Help-line

Dear Sir,

I have been a contented and successful project builder, reader of your magazine for quite a while now. With such outstanding comprehensive coverage and useful up to date information, not to mention those marvellous projects, that unanimously puts your magazine aside from the rest.

You must now be wondering why I am writing to you. It is because I am in need of some information. Being an electronic enthusiast for quite some years now, I was happily employed and able to carry out projects, now due to unexpected redundancy, I am now turning those projects into my profession.

I am now in the process of setting up a design and production workshop, specialising in the designing and manufacturing of: Disco, Group, P A, HiFi and Studio Equipment. As these units will have a robust rugged but classic look! Further to this the units will have high specifications, useful tailor-made units to suit.

With such a marvellous ornate new venture, I can not possibly let down the appearance of my units. By using the readily available commercial standard size and shapes slider potentiometers, plus the unavailability of stepped

rotary controls (pots), not to mention the control knobs. If you could be so kind as to enlighten me as to who or where I could obtain the following:

1. Slider potentiometers, with travel less than 40mm both single and stereo.

2. Stepped rotary potentiometers.

3. Stepped slider potentiometers.

4. A manufacturer who would make any of the above to my specifications and finally control knobs not available to retail outlets.

Your help will be greatly appreciated from a happy and grateful reader.

Yours faithfully,  
R. Leslie  
Wolverhampton

From one 'electronic enthusiast' to another - whirr, click, pyangg! No, but seriously, we've printed

Mr. Leslie's letter because we can't really help him, although his predicament must be shared by many. ETI would like to see itself helping those in need of technical information of the sort Mr. Leslie seeks - hobbyists and, especially, people seeking to make the best of enforced redundancy with the help of their hobby. Since we are already overstretched producing the magazine and answering specific queries about the projects we have published, there is room for a 'reader-to-reader' enquiry service, through which ETI readers could help each other.

If anyone can offer Mr. Leslie some assistance we would be pleased to forward any details. If anyone seeks help from other readers, not necessarily on matters dealing with ETI projects or features, we would be happy to publish their request in what we hope will become a special 'help line' section of the magazine.

The one thing we'd ask is that you keep your letters short, preferably sticking to the meat of the query. We will, in any case, edit them if necessary.

Please send letters for this page to: Read/Write, c/o the Editor, ETI, ASP Ltd, 1 Golden Square, London W1R 3AB. Send Help Line queries to Help Line, c/o the Editor, ETI at the same address. Please note that any letter we receive is liable to be published unless clearly marked 'Not for publication'. We reserve the right to edit letters for space reasons.

ETI



# DIGIVISION INSIDE OUT

**A digital Dallas? Computerized Coronation Street? Vivian Capel takes a look at the future of television and finds it's much the same.**

During the early days of post-war television when I worked with a television service company, engineers would often append the comment 'digital interference' to their job sheets. No, they weren't blaming interference from a nearby computer, they were few and far between in those days, and most, in any case, were analogue. Otherwise expressed, they were reporting 'finger trouble', faults brought on by the television viewer fiddling with the array of presets that adorned the rear panels and sides of the TV receivers of the day.

Digital techniques were then known only to a small coterie — in the computer industry, mainly. Such things could never be applied to audio or television. Why, how could they accommodate the vast number of valves that would be needed, to say nothing of powering them?

The coming of semiconductors changed all that, but there seemed little to be gained from abandoning the simplicity of analogue signal processing. So, domestic sound and vision reproducers have remained firmly analogue — until recently. With its narrower bandwidth, audio was the obvious candidate for digitization. The compact disc has certainly shown what advantages can be obtained by digital signal storing and processing, with its low distortion and absence of noise.

But what about television? Professional studio equipment has employed digital techniques for many years. Independent television has had a digital standards converter in use since 1972, and the numerous weird effects increasingly seen on our TV screens demonstrate the growing use of digital video effects generators in broadcast studios.

Since 1977, ITT Semiconductors has been developing methods of applying digital techniques to domestic TV receivers. Seven years later, and at a cost of some £20 million, what is claimed to be the world's first digital domestic TV receiver went on sale — the Digivision D1000.

## Reception

How does it work and what does it do? The principal source of signal degradation in any system is the transmission process — whether that be broadcasting or some form of analogue recording. The compact audio disc overcomes most signal degradation by recording

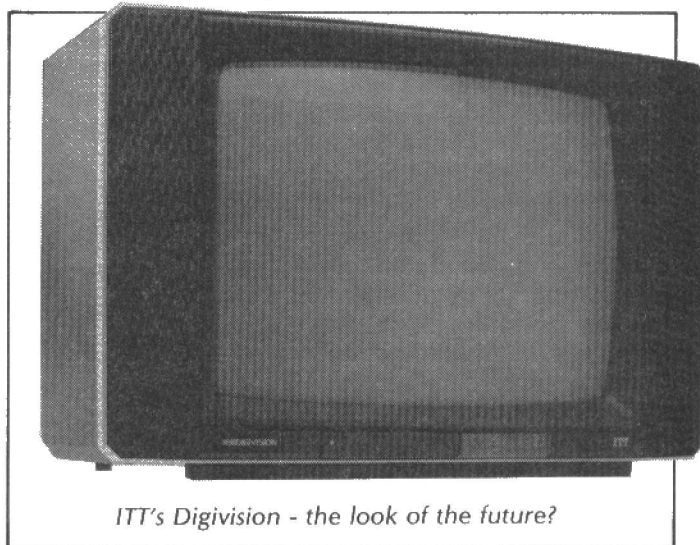
and replaying digital signals but this advantage is not obtainable with digital TV at present, because the television signal itself is not digital. The set can only do its best with whatever is presented to it in the way of a normal analogue transmission via the aerial.

Because of this, the tuner and the IF stages of the Digivision receiver are conventional, as is the vision demodulator. From that point on the digital circuits take over.

The vision signal is converted to a 7-bit digital data stream. By employing a system of averaging on alternate lines, 8-bit resolution is achieved giving 255 sampling levels. As with a conventional TV, the colour or chroma signal is processed separately from this luminance or black-and-white portion.

The eye is less sensitive to colour definition than light and shade detail, which is why the chroma signal has a much smaller bandwidth than the luminance. Furthermore, the eye is less aware of small hue differences than shade gradations. Hence, the chroma signal is represented here by 63 sampling levels, obtained by a 6-bit data stream.

Ironically, it is the sound signal that gets the best treatment digitally; a 14-bit sampling system gives 16,383 levels. This is of course as it should be, because the ear is very sensitive to the distortion produced by an inadequate number of sampling levels, whereas the eye is less critical of gradation differences.



*ITT's Digivision - the look of the future?*

## Processing

After conversion to digital signals the luminance information is filtered, the contrast is set, and black-level clamping and white balancing are carried out. A single chip is used for the video processing, and this includes the colour decoding. For PAL decoding a delay line is used in the normal analogue receiver. The function of this is to delay the signal for 64  $\mu$ s, or one complete line, in order to obtain the averaging on alternate lines to cancel phase aberrations. However, in place of the conventional glass delay line and ultrasonic transducers at each end, the delay is obtained by blocks of RAM with capability for storing the required one line. This occupies far less space than a glass delay line - only three square millimetres of chip area. The store is accommodated in the video processor chip along with the filters and other decoding functions.

The chip permits the decoding of NTSC colour signals as transmitted in America, and in this mode the delay circuit can be used as a comb filter for separation of the chrominance and luminance signals.

After processing and decoding, the digital signal is converted back to analogue. This task is performed on the same chip that carried out the A/D conversion. From there the three colour outputs are taken to conventional output stages to drive the display tube.

Deflection signals are generated digitally in a further chip in which division and count-down circuits provide both line and field scanning pulses which drive their respective output stages. These are synchronised from the digital video input.

A master clock generator provides the pulses for all the conversion and processing functions, and a microcomputer chip controls the whole operation. It scans the control keyboard which can have up to 32 keys covering brilliance, colour, and volume, among other things. Included is a phase-locked loop which provides tuning for VHF and UHF, plus a memory to store data for receiving up to 30 channels. The chip also incorporates a memory to store factory-programmed data for tube drive and timebase control. The clock generator runs at 17.73 MHz, four times the colour sub-carrier frequency.

In the sound circuit, one chip converts to digital and back again to analogue to feed the sound output stages and speakers, just as with the video signal. It seems as

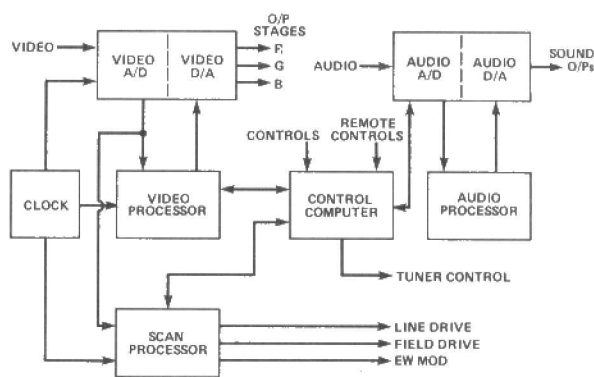


Fig. 1 Block diagram of the Digivision Circuit.

though the designers missed a trick here. If they had employed PWM (pulse width modulation) to drive the speakers there would have been no need of an analogue output stage which generates considerable distortion. In between the A/D and D/A conversions, another chip takes care of the sound signal processing. It includes the ability to deal with two-carrier TV stereo signals.

Sound reproduction is usually the lowest priority with most TV sets and the results are pretty 'lo-fi'. Here though, some attention has been given to this side of matters. The twin output stages deliver 15 watts each to two, three-driver speakers having bass-reflex loading.

## Servicing

One thing that Digivision service engineers will not be able to report is 'digital interference' — in spite of it being a digital device. There are no viewer-accessible presets, only the normal controls. One internal preset sets the HT voltage, which is common practice with conventional TV's. All other adjustments such as picture height and width, tube-drive and timebases are made by re-programming the control computer. This can only be done by using a service computer that plugs into a socket provided for the purpose. ITT has dubbed this device an 'electronic screwdriver'. Maybe, but a conventional screwdriver costs a lot less! Dealers purchasing five Digivisions get one service computer

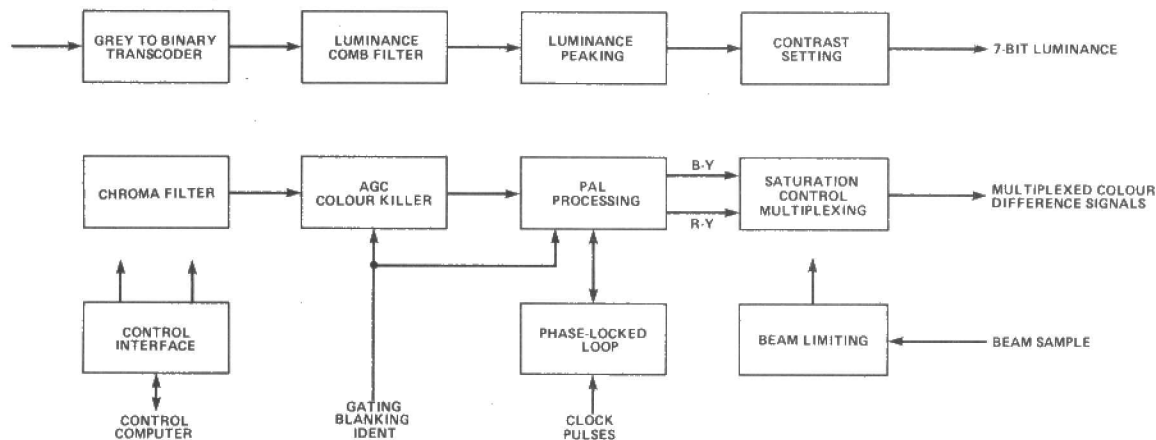


Fig. 2 Simplified function chart of the video processor IC.

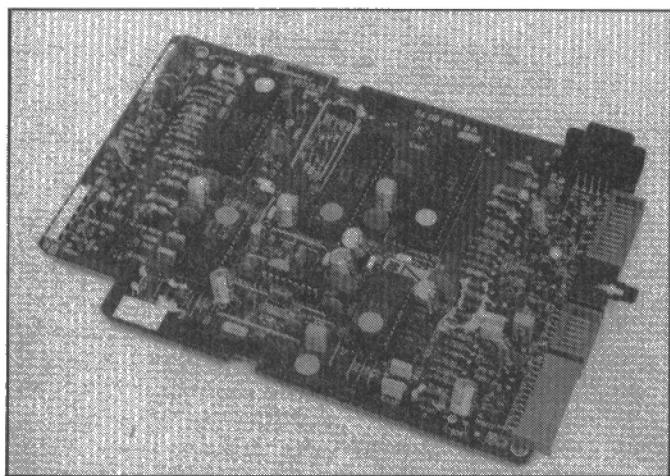


free from the makers. The snag is that owners who are qualified and prefer to do their own servicing, especially after the guarantee has expired, will be without the means to do so.

Apart from the clock generator and tuner interface IC's there are six VLSI chips. If you didn't know, that stands for Very Large Scale Integration, and just how large can be gathered from the fact that one chip can contain up to 200,000 transistors.

### Possible Enhancement

That brings us to the obvious question, is it all worth it? Are there dramatic improvements comparable to those obtained with digital audio recording? Given a good signal from the aerial and good programme material, a conventional analogue TV which is properly adjusted is capable of excellent results. What limitations there are arise from the transmission system. These are: horizontal definition, line structure — which is easily noticeable on very large screens — and mutual interference between colour and luminance signals due to the way the colour sub-carrier is interleaved into the video spectrum to save bandwidth.



*The main processor board of the Digivision.*

These, and degradation due to transmission and reception conditions, will be suffered by the digital set just as much as the analogue. Real improvement could only be expected when the transmissions themselves become digital — which is likely to be a long way ahead. What then about reliability?

The makers claim that peak performance is held longer than with conventional sets because the onboard computer monitors performance continually and makes the necessary adjustments to maintain it. However, to put things in perspective, modern TV sets need far less adjustment than did their predecessors. Most faults occur in the display tube and deflection circuits which are conventional with the Digivision. Most sets these days contain a number of chips, and all can and do break down. Statistically, the more semi-conductor elements a chip has, the greater the chance of failure. On this basis the VLSI IC's offer less prospect of longevity than the far simpler units employed in analogue receivers. All the same, there are many complex chips in daily use that have a good record of reliability and only time will tell with the Digivision.

In the absence of any major benefits to the viewer, it seems that digital television at present is an exploratory step.

The number of scanning lines could be increased. Plans are already afoot to double the line number by using 2.2 kbyte of RAM for line storage to enable each line to be traced twice. This would not increase the actual vertical definition, but the doubling of the lines would make them virtually indistinguishable, even on very large screens.

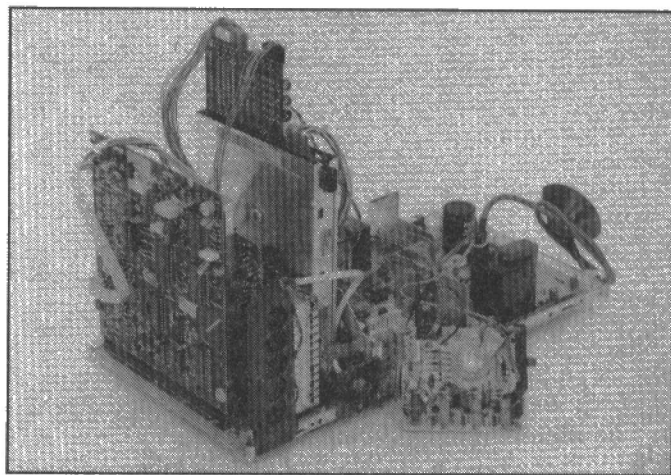
Another possibility is to use a field store that will hold a complete field of picture. By use of this the TV could be given a still-frame capability just like a video recorder. The only snag is that you could not continue viewing from where you left off, or inch to the next frame, since material transmitted while you were viewing the still frame would have passed. But some studio trick effects would be possible.

Two pictures could be displayed at the same time. With TV programmes as boring as they are, this could be a boon, as viewers could then transfer their attention to whichever seemed the most interesting! Zoom facilities could also be incorporated enabling a portion of the picture to be enlarged at will. Another possibility is the enhancement of the received signal by identifying and eliminating ghosts caused by multipath reception. With the problems caused in some areas by high rise buildings, this would give a positive advantage over analogue sets.

### Other Makers

ITT have proved to be the first in the field but others are following. The Finnish firm Salora have produced a digital receiver which is now on sale and uses the same chips as Digivision. They are the first with the smaller 20 and 22-inch screen sizes, the ITT being 26-inch. Salora call their offering the Digicomputer, which could be a little misleading. Optional extras include a satellite tuner and PAL/SECAM/NTSC converter.

We may be seeing many other makers producing digital TV's, because the ITT subsidiary Intermetall — which makes the chips at Freidberg — are supplying packages of the complete line-up of chips to such firms as Matsushita, Toshiba, Sharp and Zenith. Some 21 companies have signed up to buy the package from Intermetall. Knowing the cut-throat competition exist-



*The sound and picture goes in here and it comes out...*

# FEATURE : Digivision

ing among these giants, it is almost certain that their research teams are busily finding ways to produce their own, with sufficient differences and perhaps improvements to circumvent the patent laws.

A further chip is being added to the package from Freidberg and that is one that will process any of the existing European teletext systems (except the French Antiope). To assemble all that on one chip is quite an achievement, especially as it includes automatic switching between the systems.

There are also plans to produce a digital VHS video recorder. This could be a major step forward, as the reproduction from domestic video recorders leaves much room for improvement. It all depends on whether they can digitize the main noise and distortion producing areas. Principally, these are in the recording process itself and with present technology digital video recording using the VHS format seems very unlikely.

As for those future gimmicks, the frame store and such, these are well in the future and present sets will not be adaptable. It requires about 4 megabits for a high quality frame store, and at present 1 megabit seems the maximum for a single chip.

It appears that digital TV — along with about practically everything else — is the set prospect for the future. (I wonder if we will ever get crisp, clear, digital hi-fi telephone conversations with no clicks, crackles and noise?). Present purchasers of digital sets will have the satisfaction of being in at the start of a new technology, but at present there are few other compensations for the extra cost.

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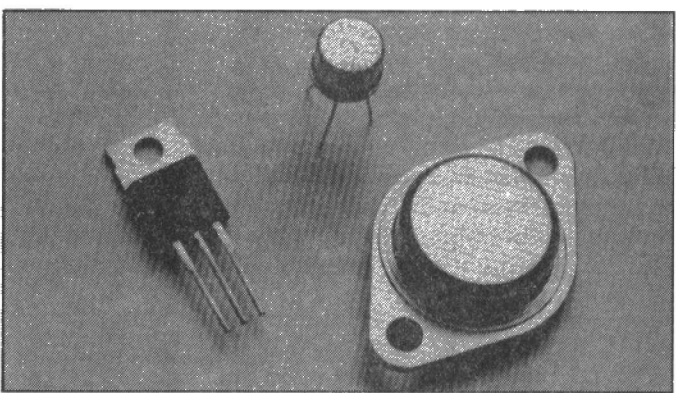
We may be biased, but we think the majority of you will get quite carried away by John Linsley Hood's article on transistors.

I looked last month at the way in which transistors were developed and how they had evolved into their present form. I now propose to look at some of the various contemporary types.

As a working electronics engineer I tend to look unsympathetically at the propaganda of the 'back to valves' brigade. The enormous scope for circuit design now available to the electronics fraternity is due entirely to the wealth of devices at our disposal. Of course, one has to know what devices are available and how to use them properly so that they give of their best, and it is also necessary to know their individual strengths and weaknesses so that one always uses the most appropriate device for the job in hand. There are a lot of them to choose from, so let us take a look.

## Small Signal Junction Transistors

These exist as small metal cans or blobs of moulded plastic with three (or sometimes four) wires, as shown in Fig. 1. There isn't much difference nowadays between the longevity and reliability of plastic and metal can encapsulations, especially since the can is often just a receptacle into which epoxy resin has been poured to hold the silicon chip in place. Metal can types, especially those which are hermetically sealed, tend to be a good bit dearer than plastic moulded types.



The chip inside the encapsulation will normally be of either the planar or the epitaxial planar type, both of which are shown in Fig. 2. Epitaxial (or epitaxial base) types have an additional thin layer of a different type of silicon grown on the chip by vapour phase techniques before the other diffusions have been made. They are cheaper and generally work better than other types and are therefore the most commonly used.

Typical power dissipations for small signal plastic transistors range from about 250 to 650 milliwatts. Metal can ones will typically handle from 300-1000 milliwatts dissipation. It is good practice to keep dissipations down to about half of the rated maximum.

Small signal NPN and PNP transistors can generally be regarded as 'maids of all work' in the small circuit field. They are easy to use, inexpensive, reasonably difficult to damage, and will work well when used within their limits. Certain types are particularly suited for use in very low-noise, low impedance applications. Because they can be used in complementary symmetry arrangements, some very crafty circuit layouts are possible. The circuit symbols for these devices are shown in Fig. 3a.

## Darlington Transistors

These consist of a pair of small signal transistors coupled together in one case. They are available in NPN and PNP types and the circuit symbol for the NPN type is shown in Fig. 3b, with my own preferred symbol shown in Fig. 3c. They are similar to other junction transistors except that they have current gains of between 20 000 and 50 000 and relatively high input impedance. Typical input impedances would be from 100k to 250k for output currents of between 2 and 10mA, which is the range

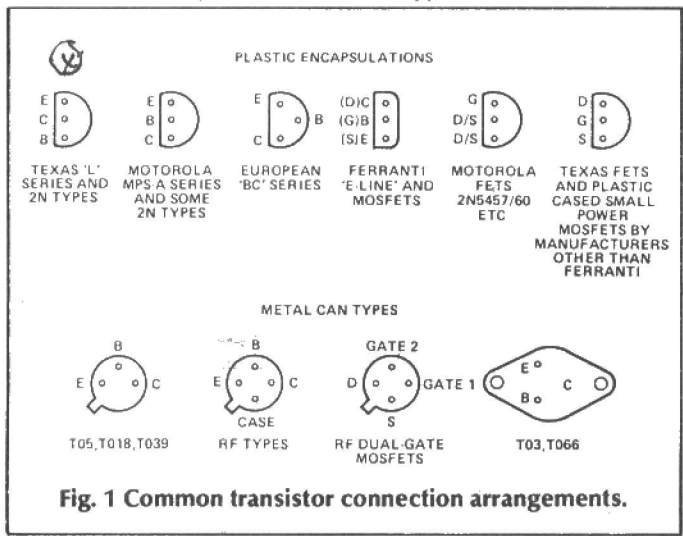
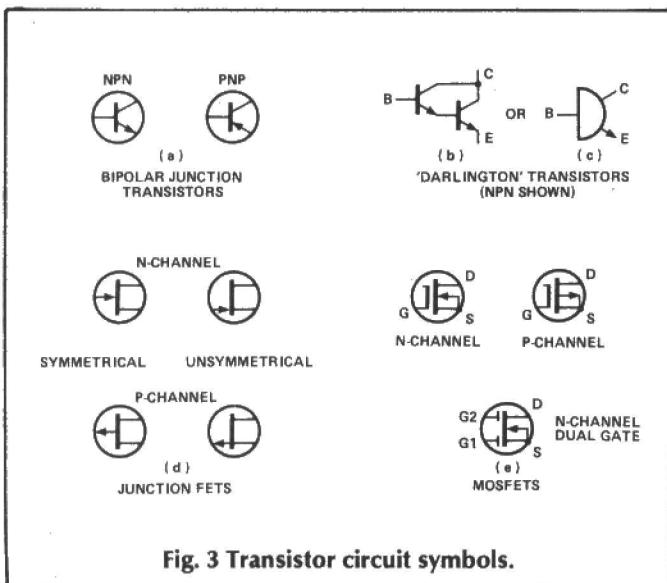
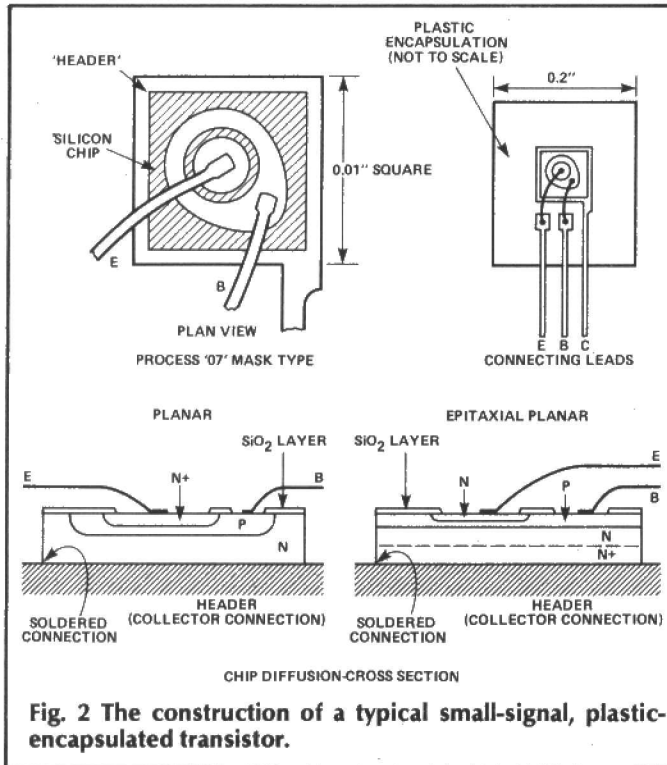


Fig. 1 Common transistor connection arrangements.



over which they work best. The Motorola MPSA-12/14 (NPN) and the MPSA-62/64 (PNP) are good examples. Inevitably they are a bit dearer than standard single transistors.

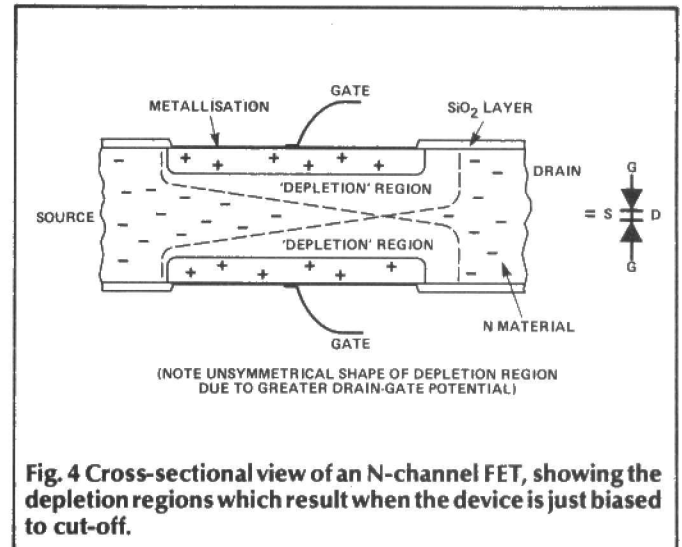
## Junction Field Effect Devices

These were the original high impedance transistor types and are represented in circuit diagrams by the symbols shown in Fig. 3d. Their physical construction is shown in Fig. 4.

They differ from junction bipolar transistors in that their input terminal, the gate, is normally non-conducting. In fact, it is a reverse biased junction diode, and the only current which will flow is the normal reverse leakage current of such a diode. Typical input impedances for good quality devices of this type range from ten thousand to a million megohms.

Contrary to popular legend, these devices will not

normally be damaged by static charges any more than any other small signal diode would be, so they don't need especial care in use. They come into their own where very high input impedances are needed, and where the extra cost of using a junction FET is justified — they are about five times the cost of an equivalent bipolar device. The better examples are also less noisy in high impedance circuitry than bipolar devices but one needs to choose carefully because some of the cheap and cheerful junction FETs are not very good in this respect.

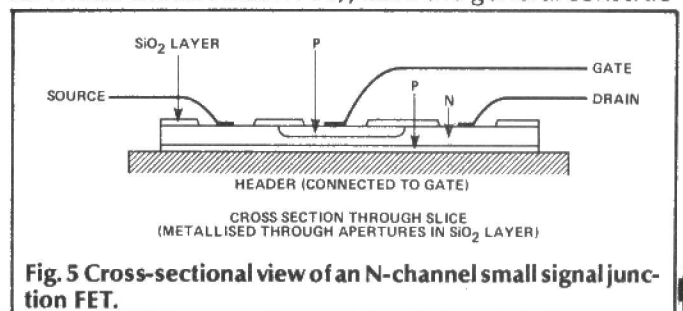


Junction FETs also make good RF amplifier devices at frequencies up to about 300MHz, and can offer very low noise in this application. In circuitry, they will tend to have a lower stage gain than bipolar devices, unless a very high impedance output load is employed which usually means an active load of some kind. They have a very flat drain current/drain voltage characteristic which makes them good at rejecting HT line ripple effects, and also allows them to be used as nearly ideal constant current sources.

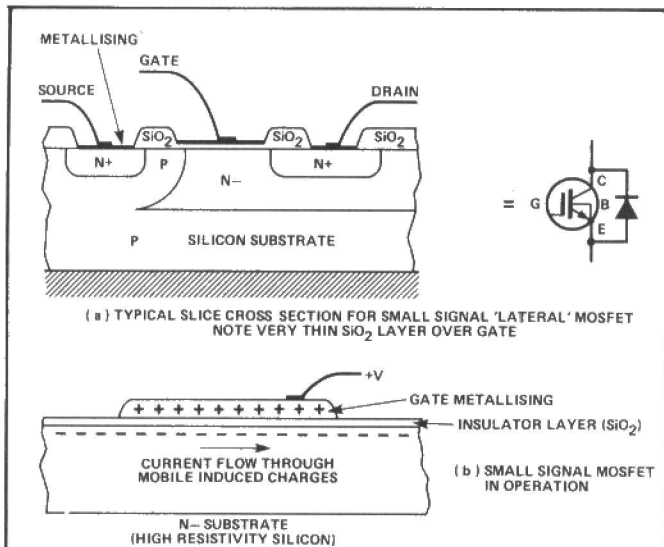
The chip construction of a junction FET is shown in Fig. 5. The chip acts as a thin conducting layer of P-type or N-type silicon (germanium is almost never used, though it is still used sometimes in bipolar devices), into which a depletion layer will expand, narrowing and finally cutting off the undepleted layer through which current may flow as the reverse bias potential applied to the gate is increased. Junction FETs are usually, though not always, symmetrical, so source and drain may be interchanged.

## Small Signal MOSFETs

These devices, sometimes also known as insulated gate field effect transistors or IGFETs (MOSFET stands for Metal Oxide Silicon FET), have the general construc-



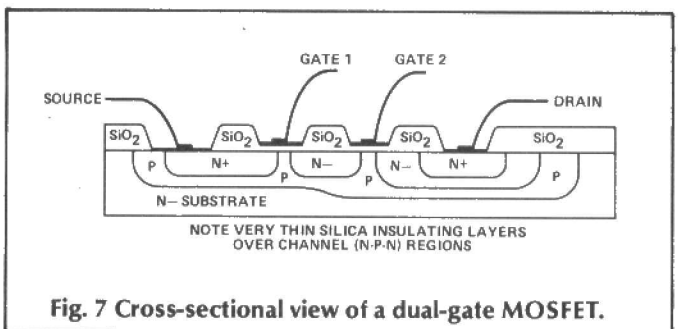




**Fig. 6** Cross-sectional views showing the construction and operation of a MOSFET.

tion shown, for the wafer, in Fig. 6a. They work on the principle that if a charge (i.e., a voltage) is applied to an insulating layer, a charge of the opposite type will be attracted to the other face, as shown in Fig. 6b.

If that other face happens to lie in the body of a slice of high impedance (low impurity, or intrinsic) silicon, then current will flow in that charge layer. If the insulating layer is very thin, only a few volts need be applied to the gate in order to make current flow through the charge layer. The layer, which can be less than a micron thick, is usually made by oxidising the outer face of the silicon



**Fig. 7** Cross-sectional view of a dual-gate MOSFET.

slice, so that a metal layer can be deposited on it without making contact. It is normally capable of withstanding an applied voltage of some 20 or 30 volts only, and can be damaged by static charges or careless handling.

In order to make these devices a little less fragile in normal day to day use, it is customary to incorporate on the chip a couple of back-to-back zener diodes across the gate-source connections. This reduces the input impedance to perhaps a million megohms. It is possible to get unprotected MOSFETs which have a higher input impedance, but these need careful handling.

The most common variety of small signal MOSFET is the dual gate type shown in Fig. 7. This was specifically designed as a device for RF amplification and mixing in radio and TV tuners, and is usable up to a few hundred megahertz. The second gate can be used to screen the input signal gate from the output signal on the drain, permitting stable RF amplification. In this application, it acts in a similar way to the screened-grid or RF pentode type of valve. I have shown the circuit symbol for these transistors in Fig. 3c.

All of these MOSFETs require a forward voltage applied to the gate electrode to cause them to conduct.

	TYPICAL INPUT IMPEDANCE	TYPICAL STAGE GAIN	OUTPUT IMPEDANCE (COMMON EMITTER)	TYPICAL MAXIMUM WORKING FREQUENCY	NOISE FIGURE (dB) (MINIMUM)	TYPICAL (MAX) WORKING VOLTAGE	TYPICAL (MAX) WORKING CURRENT	COMMENTS
SMALL SIGNAL JUNCTION TRANSISTORS	0.5-20k	40-200	200k +	300MHz	1dB	150V	500mA	NOT VERY LINEAR WITHOUT NFB
SMALL SIGNAL DARLINGTON TRANSISTORS	250k	100-500	200k	100MHz	6dB	40V	1A	TEMPERATURE SENSITIVE
JUNCTION FETS	$10^{11}R$	10-30	10M	400MHz	2.5dB	30V	15mA	LINEAR
DUAL-GATE MOSFETS	$10^{12}R$	50-100	500k	500MHz	2dB	20V	20mA	CAN BE DAMAGED BY STATIC CHARGES
SMALL POWER MOSFETS	$10^{12}R$	50-200	250k	500MHz	6dB	100V	1A	CAN BE DAMAGED BY STATIC CHARGES- VERY LINEAR
POWER TRANSISTORS (NPN)	10-200R	10-30	5k	40MHz	N/A	400V	25A	CAN SUFFER FROM 'HOLE' STORAGE EFFECTS
POWER TRANSISTORS (PNP)	10-200R	10-30	5k	10MHz	N/A	100V	15A	SOMEWHAT SLUGGISH & SUFFER FROM 'HOLE' STORAGE
POWER DARLINGTONS	20k	50 +	5k	4MHz	N/A	120V	15A	SLUGGISH AND SUFFER FROM 'HOLE' STORAGE
POWER MOSFETS	100M +	50 +	10k	500MHz	POOR	750V	10A	HIGH INPUT CAPACITANCE-PRONE TO OSCILLATE IF NOT PREVENTED
POWER FETS	10M +	10 +	5k	100MHz	N/A	?	?	HIGH OPERATING CURRENT REQUIRED

**Table 1** A comparison of the characteristics of different transistor types.

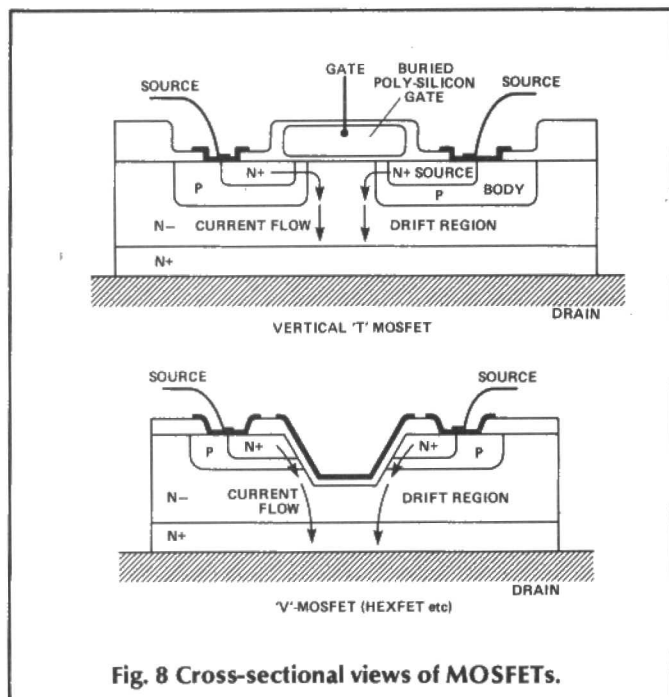


Fig. 8 Cross-sectional views of MOSFETs.

This will be positive in the case of an N-channel MOSFET (operating on a positive DC supply line) and negative in the case of the less common P-channel types. Small signal devices of this type will typically have a mutual conductance or  $G_m$  of a few milliamps per volt. This allows a simple calculation of stage gain from

$$\text{Gain} = G_m \times R_L$$

where  $R_L$  is the effective load impedance.

Recently, and to my great delight, small signal versions of the T-MOS type of power MOSFET have been introduced. These have a slightly different type of chip construction to the normal small-signal MOSFET, and I have shown this in Fig. 8. Their big advantage is that they can withstand drain voltages of up to about 100V, whereas the average dual-gate device or small signal junction FET can only cope with some 20-30V.

By comparison with bipolar transistors, MOSFETs are much more linear in their characteristics and do not suffer from operational problems such as thermal runaway and hole storage. The absence of this latter defect makes small signal TMOS devices considerably better than bipolar junction devices when used in the class A stages of audio amplifiers, as in the case of the Audio Design power amplifier shown in ETI last summer.

The circuit symbol used for the TMOS device is the same as that used for other MOSFETs except that they are only available in single gate versions.

I have shown the normal operating characteristics of the various small signal transistors in Table 1, and a group of curves showing their input voltage/output current characteristics in Fig. 9.

## Bipolar Junction Power Transistors

These are heavier duty versions of the small signal transistors we have already come across, and range in current handling capacity from an ampere or so for some of the small plastic encapsulated types with a metal cooling tag to 400 amperes in the case of some of the big industrial devices.

Permitted dissipations, with adequate heat-sinking,

range from one to many hundreds of watts, and maximum collector voltages can be up to 500-1000 volts in specialised types, with 60-150V being more common in easily found devices such as the 2N3055 or 2N3442.

There isn't a big difference in price between the plastic encapsulated types and the hermetically sealed metal TO66 or TO3 versions, so, for DIY projects where one isn't buying a lot of power transistors, the metal can versions may be preferable. They are certainly easier to cool.

Power junction transistors are available in NPN and PNP types, just like small signal devices, but the PNP ones tend to be a bit slower in action and a bit less burst-proof than the NPN ones. One should beware of assuming that because they are complementary in characteristics they can be treated as identical. A nice comment I once heard was that 'NPN and PNP power transistors are as similar as a man and a woman of the same height and weight'.

The transition frequency of a power transistor, that is, the frequency at which the current gain falls to unity, will usually lie within the range 4-20MHz, which is considerably lower than the transition frequency of a typical small signal device which would probably be between 100 and 400MHz. In addition to being more sluggish than small signal types, power transistors also have lower current gains. Whereas a small signal junction transistor has a typical current gain of 100-500, a power device might have a current gain of only 15-80, with the lower

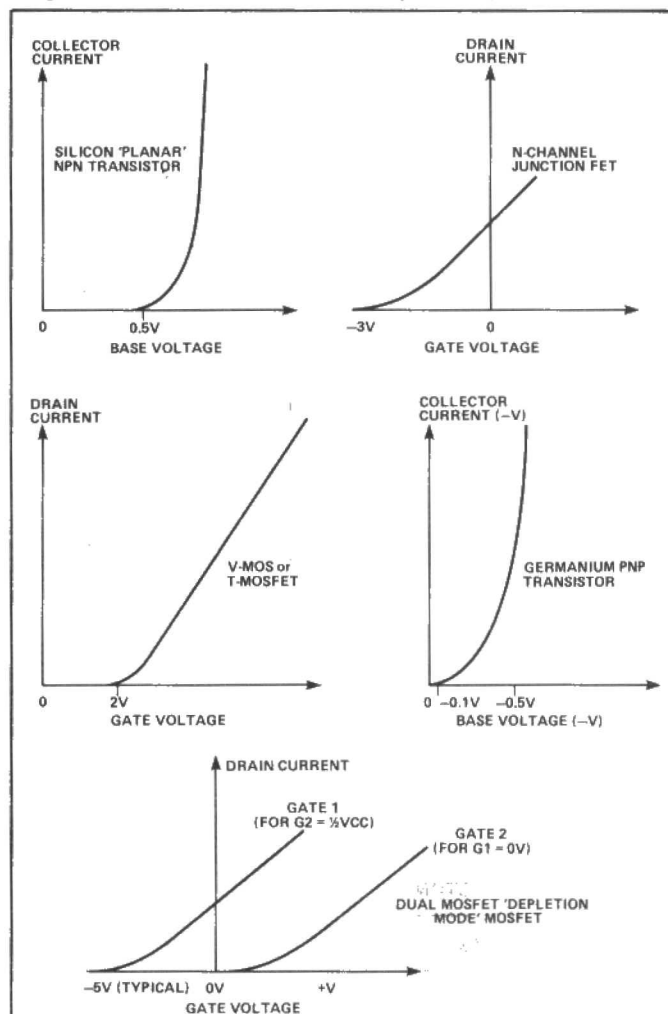


Fig. 9 Graphs showing the input voltage/output current characteristics of different types of transistor.



values usually being found at higher collector currents.

Since this can occasionally be a nuisance where high output currents are required (remember that the required drive current is the output current divided by the current gain), compound Darlington power transistors are available which have current gains in the range 1000-10,000. These are very useful, especially since they are not a lot dearer than single power transistors. However, they do have snags, of which the chief are that their output current for a given forward voltage is very temperature dependent and that they are, if anything, even more sluggish than ordinary power output devices.

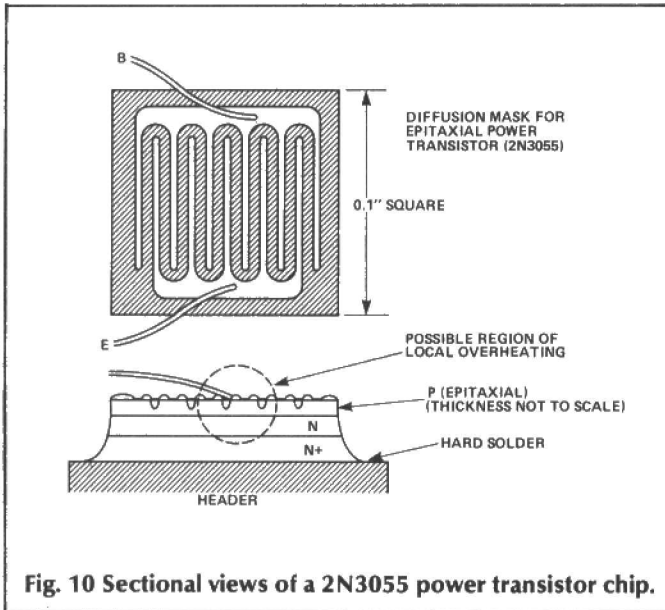


Fig. 10 Sectional views of a 2N3055 power transistor chip.

The major problem with bipolar junction power transistors is that of secondary breakdown. This arises because the forward voltage of a conducting semiconductor junction — such as the base emitter junction in a transistor — drops as the temperature of the junction rises. So, in a power transistor, which has a typical chip cross-section as shown in Fig. 10, if the current flow through the transistor makes the chip get hot, it is likely that some parts of its area will get hotter than others. The base-emitter junction forward voltage in these regions will then drop, and more current will flow through this region. This will cause the collector current opposite these areas to increase, which will make the areas concerned still hotter . . . and so on, until the device goes phut.

The only way to avoid this is to make sure that such transistors are always operated well within the 'safe operating area' specified by the manufacturers. Ensuring that this condition is always met can be tricky in equipments designed to drive dynamic loads such as loudspeakers or motors. Nevertheless, it is practicable.

## Power MOSFETs

Small signal dual-gate devices have a lateral current flow, that is, in a direction parallel to the surface of the wafer, and consequently have a fairly high channel resistance. In order to use the MOSFET principle in power devices, a means had to be found of lowering the conducting resistance. The chip construction employed is shown in Fig. 8.

In this arrangement, the current flows in a vertical direction (ie., at right angles to the surface of the wafer). This means that the channel length is defined not so

much by the accuracy of the wafer masking during successive diffusions as by the actual thickness of the diffused layer, which can be very narrow indeed and quite accurately controlled.

Power MOSFETs are very fast devices by comparison with the relatively sluggish bipolar power devices. They are also very much more linear, although they don't have such a high gain. Apart from the fact that they require a forward bias of 2-3V to force them into conduction, they are similar in characteristics to output 'Beam-tetrode' valves, but, of course, much more compact and free from the need for a cathode heater supply.

Their main drawback is that they are inclined to see wires connected to their pins as small inductances, whereupon they will happily oscillate at a few hundred megahertz until they burn out either themselves or some other, weaker link. This can be avoided simply by the use of a suitable 'gate stopper' resistor, in the range 250R-2k $\Omega$ . They also have an absolute limit on the voltage which can be applied to their gates in either a forward or a reverse direction. This usually requires both attention to the circuit design, and some form of zener diode protection.

Cost considerations apart, I think that they have overtaken bipolar junction transistors as power amplifier output devices provided that they are correctly employed. Moreover, they are quite immune to 'secondary breakdown', and whilst they do have other problems, there is nothing that cannot fairly easily be avoided.

Power MOSFETs are currently available in working voltages up to 500V, and current ratings up to 50 amperes — although not both in the same package. Maximum power ratings are now up to the 150 watt mark, and rising.

Combination devices are beginning to appear, consisting of small power MOSFETs driving large power bipolar transistors, all on the same chip and in the same package. They combine the easy drive characteristics of power MOSFETs with the very high current capabilities of power transistors, mainly for uses like motor driving. Also appearing are power MOSFETs with built-in logic elements, to give muscle to low-power logic circuitry.

## Power Junction FETs

These were introduced by Sony, in Japan, just before the general acceptance and widespread manufacture of power MOSFETs. They are, in effect, just bigger versions of the small signal devices described above, with higher voltage, current, and dissipation ratings. The few audio amplifiers built by Sony using these had a good reputation.

I am not sure whether the success of the 'vertical' power MOSFET will mean that power junction FETs (which behave in a manner very similar to that of valve triodes) have now become obsolete, or whether in the fullness of time they will be made by other manufacturers and become widely available.

I propose to look next month at the topic of transistor parameters,  $y$ ,  $z$  and  $h$ , and the techniques of performance calculations using these. I will also look a bit more closely at the way in which transistors are employed, with particular reference to some of the hidden snags, since the quality of the designs which we make for ourselves will depend a lot on our ability to avoid unforeseen problems and to choose the most appropriate device and the best way of using it. After all, it often costs no more to make up a good design than a less satisfactory one, and the same components may serve for both.

ETI

# 6802 EVALUATION BOARD

The 6802 is not a microprocessor we have paid a lot of attention to in the past. C.P. Atkins has come up with this straightforward design for those who would like to get to know it a little better.

This project was designed for people who wish to break into the world of microprocessors. Many such systems have been designed in the past but most are still too complicated for the hobbyist to understand. Other people buy expensive computer systems and find they still know very little about the micro and how it works, quite often because of a monitor program which controls every move.

The project described is very simple and of basic design yet forms a powerful base upon which to design complex systems. It was primarily designed to allow people to teach themselves microprocessor hardware design and machine-code, allowing the user not only to program the circuit but also to program the vectors. Hex displays are added so that the programmer can actually see the result. In time the user should find it unnecessary to keep designing new circuits and just reprogram the board for each requirement instead.

The draw back with this project is that every time you wish to change or modify the program you will have to reprogram an EPROM, unless you are lucky enough to have access to an EPROM emulator. Because most of the people likely to construct this project will own or have access to a computer, I have also designed an EPROM emulator which will run the board, and this will be described in a future article. Simply by loading an area of RAM with micro-code and then isolating the RAM from the computer, the 6802 board can be made to think it is addressing EPROM. In this way machine code can be

changed with care and can also be stored on tape or disk when a program is completed or modified. By building up in this way a powerful system can be put together quite cheaply.

## The 6802 Microprocessor

The 6802 microprocessor was used because it has the familiar 6800 instruction set, but it also includes some additional features. The 6802 is an eight bit microprocessors which contains all the registers and accumulators of the present 6800 plus an internal clock oscillator and drives. It also has 128 bytes of RAM at hex address 0000 to 007F. The first 32 bytes at hex address 0000 to 001F may be retained in a low power mode by using Vcc standby, thus retaining memory on powerdown, but this feature is not incorporated on the evaluation board.

The processor has three sixteen bit registers and three eight bit registers. These are the Program Counter, Stack Pointer, Index Register, A and B accumulators and a condition code register or status register. The program counter is a two byte (16 bit) register that points to the current program address. The stack pointer is also a two byte register and contains the address of the next available location in an external push down, pop up stack. This stack is normally the part of the RAM which can be put anywhere in your memory map.

The index register is a very useful register because it is also two bytes wide and can be used as a general purpose register or, more importantly, for the indexed mode of memory addressing. Two eight bit accumulators are used to store

results from the arithmetic logic unit (ALU). The last register mentioned is the status register or condition code register which holds the condition flags of the ALU. Only the first six bits are used, the last two being held at one. The flags are Negative (N), zero (Z), overflow (V), carry from bit 7 (C), and half carry from bit 3 (H). These bits of the condition code register are used to test conditions for the conditional branch instructions. Bit 4 is the interrupt mask bit (I).

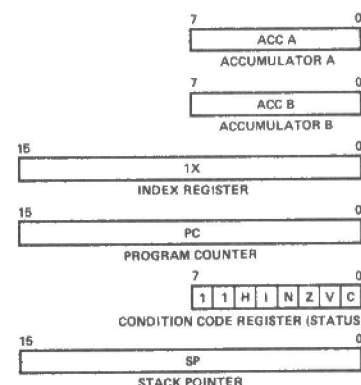


Fig. 1 The registers provided on the 6802.

The control and timing signals for the 6802 are identical to those of the 6800 except that TSC, DBE, 01, 02 and two unused pins have been eliminated and some signal and timing lines have been added. These are RAM enable (RE), crystal connections Extal and Xtal, memory ready (MR), Vcc standby, and enable 02 output (E).

The internal oscillator is crystal controlled, but other clocks may be used if desired. The connections are for a series resonant crystal. A divide-by-four circuit is



included, so a 4MHz crystal is used and the board effectively runs at 1MHz.

The 6802 has a set of 72 different instructions which are exactly the same as those of the 6800. The instruction set is very elegant (unlike, for example, the instruction sets of the Intel 8080 and 3085 micros) and for this reason is ideal for learning with. The full instruction set is given in a book called "6800 microprocessor applications manual," which any constructor who is serious about learning micro-programming should purchase.

The 6802 uses the  $\overline{\text{RESET}}$  signal for its start and restart procedures. A low on the RESET input causes it to go to address FFFE H and fetch the most significant byte of the restart address stored there. The 6802 then increments its program counter to FFFF H and fetches the least significant byte of the restart address stored there. While this signal is low all the registers are cleared and the interrupt mask bit is set. This is bit 4 in the condition code register.

The restart address is loaded into the program counter and fetches its next instruction from that address. Since the 6802 always goes to FFFE H and FFFF H to get the RESET vector address, the user must ensure that the starting address of the EPROM is stored there. This is 8000H on the 6802 evaluation board (H means hex).

## Interrupts

There are three different types of interrupts: non-maskable interrupt (NMI), interrupt request (IRQ) and a software interrupt. The non-maskable interrupt is, as the name suggests, not maskable. A low on this pin causes the processor to finish its current instruction and push the return address, index register, accumulators, and condition code register on the stack. The 6802 then goes to address FFFC H to get the most significant byte. After that it goes to FFFD H to get the least significant byte. These two bytes are then loaded into the program counter and the interrupt sub-routine is started somewhere in memory.

The interrupt request works a little differently because it is maskable. A low on the IRQ pin will have no effect unless the interrupt mask has been cleared. If

The board contains just seven chips. These are one 6802 microprocessor, one 2716 EPROM, one 7400, two 6821 PIA's (peripheral interface adaptors) and two TIL 311 hex displays. The microprocessor is connected up in a minimum configuration, which is to say that there are no fancy extras.

The data bus is 8 bits wide and is connected to both PIA's and the EPROM. The address bus is 16 bits wide. A0 to A10 are fed into the EPROM giving a memory area of 2K. A15 is taken off the bus, inverted through a two input NAND gate, and used to enable the EPROM via pins 18 and 20. The 2K memory starts at hex address 8000H. This figure is arrived at in the manner shown in Fig. 3.

A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BINARY
8				0				0				0				HEX

Fig. 3 Derivation of the memory start address.

The end of the EPROM is 8000 + 2K which is 87FF. When the reset switch is pushed for a restart the micro thinks it is looking at address FFFE but in this case it is 87FE. So our reset or restart vectors are stored in 87FE and 87FF. Since the EPROM starts at address 8000H, 80H will be stored in address 87FE and 00H will be stored in 87FF. Obviously if the EPROM was being programmed in an external programmer the 8000H would be the same as 0000H.

Decoding of the PIA's is made simple by the number of chip enables the 6821 has to its credit. RS0, RS1, and CS1 are connected to A0, A1, and A2 respectively, and this is the same on both PIA1 and PIA2 (IC3, IC4). On PIA1 (IC3) the four register addresses were decoded for 5004H to 5007H, so A14 was connected to CS2 and A12 is Nanded with the valid memory address line and connected to CS0. PIA2 is decoded for 4004H to 4007, so A14 is connected to CS0 and A15 is connected to CS2. The R/W, Reset, and E(02 clock) signals are straightforward connections to similar pins on the micro.

That leaves the  $\overline{\text{IRQA}}$  and  $\overline{\text{IRQB}}$

it has been cleared an  $\overline{\text{IRQ}}$  input will cause the 6802 processor to push the return address, index register, accumulators, and condition code register on the stack after it has finished its current instruction.

It then goes to address FFF8H to get the most significant byte and to FFF9H to get the least significant byte. The processor then sets the interrupt mask so that no other IRQ interrupt routine can start, after which the program counter is loaded with the contents of FFFH and FFFG H and the interrupt routine starts.

Note that NMI has a higher priority than that of IRQ. On the

signals. These have all been linked together and connected to the  $\overline{\text{IRQ}}$  and NMI signal on the micro, just to keep things simple. The remaining 20 pins on each chip, namely PA0-PA7, PB0-PB7, and the four control lines CA1, CA2, CB1 and CB2, are all connections to the outside world. It is from here that you will see the results of the program you have written.

To help you to see this, two TIL 311 hex displays have been linked to the PA0-PA7 lines of PIA 1. These displays take one four bit word and decode and drive the seven segment display. So, using your PIA data register as a memory location, you can display your answer or the result of a program. These displays

are also latched so a result will stay until changed. Including these eight lines, there are thirty two input/output lines and eight control lines, which is more than you would get in a home computer.

The 6802 has an oscillator and a driver circuit, so the clock is produced simply by putting a 4MHz crystal between the XTAL and EXTAL pins of the micro (pins 38 and 39). Because the circuit is so small, pull up resistors are fitted to some of the signals. In a bigger system with more chips these signals would automatically be dragged up.

For our use some signals are held high. These are RAM enable (RE), memory ready (MR) and Halt. Other signals that are in operation but are pulled-up are the interrupt lines, (pins 4 and 6), the VMA (valid memory address) signal which should be gated to the peripheral chips in some way, and the Reset signal which is also connected to a micro switch for use with restart procedures. This leaves the BA (Bus Available) signal which we are not really interested in. This is left disconnected.

evaluation board NMI and IRQ are linked together and connected to the interrupt pins on the 6821 PIA's, so that all the interrupts are controlled via the PIA (peripheral interface adaptors) handshake lines. These are CA1, CA2, CB1 and CB2, and these will be explained later.

The software interrupt request

MS VECTOR	LS	DESCRIPTION
FFFE	FFFF	RESET
FFFC	FFFD	NON-MASKABLE INTERRUPT
FFFA	FFFB	SOFTWARE INTERRUPT
FFF8	FFF9	INTERRUPT REQUEST

Fig. 2 The interrupt vector byte locations.

## HOW IT WORKS

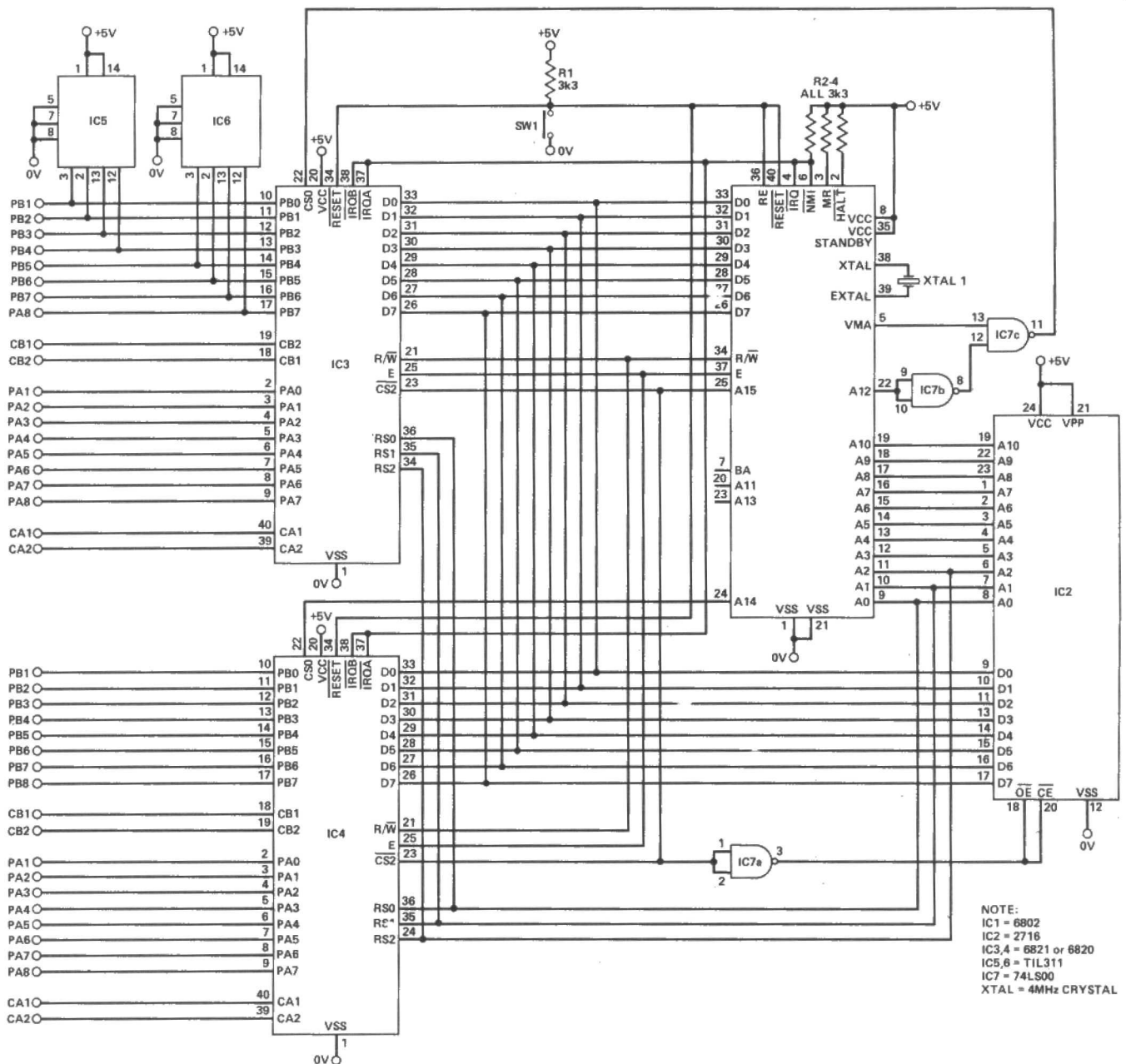


Fig. 4 Circuit diagram of the evaluation board.

is controlled by micro-code, and registers are stored on the stack. The program counter is loaded with the contents of FFFAH and FFFBH and then jumps to the interrupt routine in memory. It can also be used as a break function.

### Address Modes

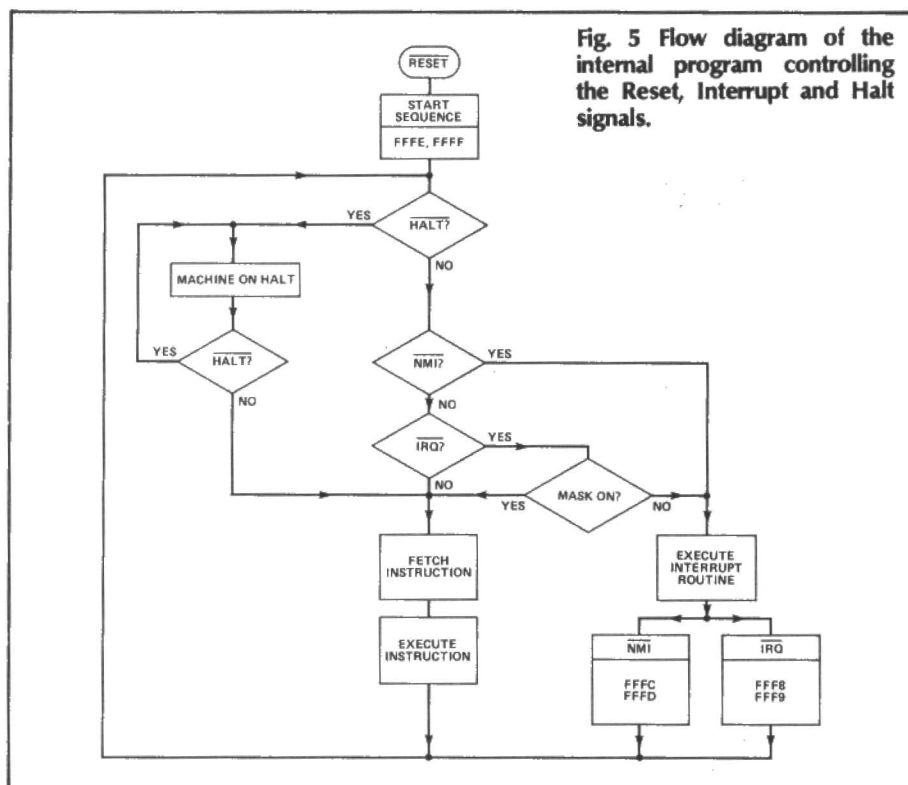
There are seven address modes that can be used by the programmer. They are:- Accumulator addressing, immediate, direct, extended, indexed, implied, and relative addressing.

In direct addressing, the 8 bit address of the operand must be stored in the lowest 256 memory locations, from 0000 to 00FF,

Direct addressing is sometimes called base page addressing because the operand must be in the first 256-byte page of memory. The 6802 uses address locations FFF8 to FFFF to store reset and interrupt addresses so as to keep the lowest 256 addresses free for direct addressing.

An example of this mode is the ADD \$09 instruction, which adds the contents of memory location 09H to the contents of the A accumulator and leaves the result in accumulator A. The advantage of this mode of addressing is that it is quicker than extended addressing because it uses two instructions instead of three.

Extended addressing uses the second and third bytes of the instruction to store the address of the operand, a rather different approach to that used in the Intel and Zilog processors. The second byte contains the high order address byte and the third byte contains the low order address byte. For example ADDA \$073A would be written in three memory bytes as BB 073A. This instruction adds the contents of memory location 073A to Accumulator A. Extended addressing is used for all memory beyond \$FF, but can be used for memory below that point. Note that \$ also denotes Hexadecimal in 6802 assembler. As an



example, compare these two instructions:

Direct LDAA FF ➔ 96FF  
Extended LDAA 00FF ➔ B6 00FF

They both have the same effect.

With indexed addressing, the operand is obtained from an effective address. The address is calculated by adding the offset number in the second byte of the instruction to the contents of the 16 bit index register. For example, suppose the index register contains a base address of 4321H. The instruction Add A \$30 in index addressing first calculates the effective address from which it will get its operand by adding the displacement of 30 H to the base address of 4321H. This gives an effective address of 4351. The 6802 then fetches the byte from memory at the effective address of 4351H, adds the contents to Accumulator A, and then leaves the result in Accumulator A.

In the implied addressing mode the operand address is contained in the instruction opcode. For example the command 'DEX' is simply written as 09. Only one byte is used in implied addressing.

In relative addressing a displacement contained in the second byte of the instruction is added to the program counter. The next instruction is fetched from the address. The displace-

ment is stored in the second byte, and the most significant bit of this second byte is the sign bit which allows the displacement to be positive or negative. A number from -128 to +127 can be derived.

Because the program counter automatically increments after each fetch, the displacement is added to the address after that in which the displacement byte was stored. Therefore, when measured from the instruction address, the relative addressing range is -126 to +129 addresses. When jumping to a location you actually state the address you wish to jump to. The easy way to remember relative addressing is to bear in mind that you always branch or jump relative to a memory location. For example:

	0050	
Branch	0051	20 FE ↑
	0053	
Jump	0050	
	0051	6E 0050 ↑
	0054	

The above two examples have the same effect, which is to go back one address space.

Accumulator addressing is a special case of implied addressing. The operand is one of the accumulators and this is indicated in the op code for the instruction. An example of this would be CLR A which is a one-byte code.

Little has been said so far about the Peripheral Interface Adaptors, of which there are two on the evaluation board. In effect, it will be these chips which the operator will program, so an insight into their operation will be useful.

An input/output port must provide a versatile programmable interface between the micro-processor and the external system devices (peripherals). These devices or peripherals can be simple lamps, switches or keyboards or more complex devices such as tape recorders, visual displays or other circuits. There are no special instructions for the PIA because, as far as the 6802 is concerned, it appears as a block of four memory addresses which can be read from or written into like any other RAM.

The addresses chosen must be consecutive and in the case of the evaluation board these addresses are 5004H, 5005, 5006 and 5007 for PIA1 (IC3). For PIA 2 (IC4) the addresses 4004, 4005, 4006 and 4007 are used. The eight data lines of the PIA are simply connected to the MPU data bus as normal and it will be noticed that several control lines are also connected between the two as discussed earlier.

Small differences aside, the PIA can be considered as two identical halves, side A and side B each having eight data (I/O) input/output lines and two special lines used for control or handshake purposes. To avoid repetition the A side only will be described.

PA0 to PA7 are data I/O lines which can be used as either inputs or outputs dependent upon how the programmer writes the initialisation routine. You could, for example, programme three lines as inputs and five as outputs. CA1 and CA2 are peripheral control lines; CA1 is always an input but CA2 can be initialised as an input or output.

There are three registers for each half of the PIA but one register serves two purposes. The Control register may cause some problems as it contains all the control flags. At this stage we are only concerned with bit 2, because it is this bit which decides which register has this memory address. When bit 2 is 0, the address 5004 (4004 for PIA 2) belongs to the direction register. When bit 2 is 1 the address 5004 belongs to the data register. The remaining bits are all connected with the behaviour of the control



## PARTS LIST

### RESISTORS

R1-R5 3k3

### SEMICONDUCTORS

IC1 6802  
IC2 2716  
IC3,4 6821 OR 6820  
IC5,6 TIL 311  
IC7 74LS00

### MISCELLANEOUS

SW1 SPDT micro switch  
XTAL1 4MHz crystal  
PCB; IC sockets — 3 off 40 pin, 1 off 24 pin and 3 off 14 pin; 42 off PC terminal pins.

## BUYLINES

Everything here is widely available with the possible exception of the TIL 311 display ICs, and these are sold by Technomatic. The PCB is available from our PCB Service.

pheral control lines CA1, CA2, CB1 and CB2. A detailed explanation can be found on a Motorola 6821 applications sheet.

CA1 and CA2 only are shown in Fig. 8, but side B is the same (CB1 and CB2). The illustration may be a bit confusing, and for this reason some examples will be given later. For simple programming little knowledge is needed of the control register, but as you progress an understanding will become essential.

## Construction and Testing

The complete project is contained on one, small, double-sided PCB. The tracks are necessarily very close together so great care must be taken during soldering to ensure that adjacent tracks are not accidentally bridged. Terminal pins are used for the external connections and these should be pushed through the board before any other components are installed. IC sockets are recommended and these should be soldered into place next, followed by the switch, the resistors and the crystal. Finally solder the display onto the board and then insert the ICs into their sockets, taking care that they are the right way around.

When the board has been assembled, check it carefully and then connect up the 0 and 5V rails. The TIL 311 displays should illuminate and show the letters FF. If all is well, the next stage is to try a test program.

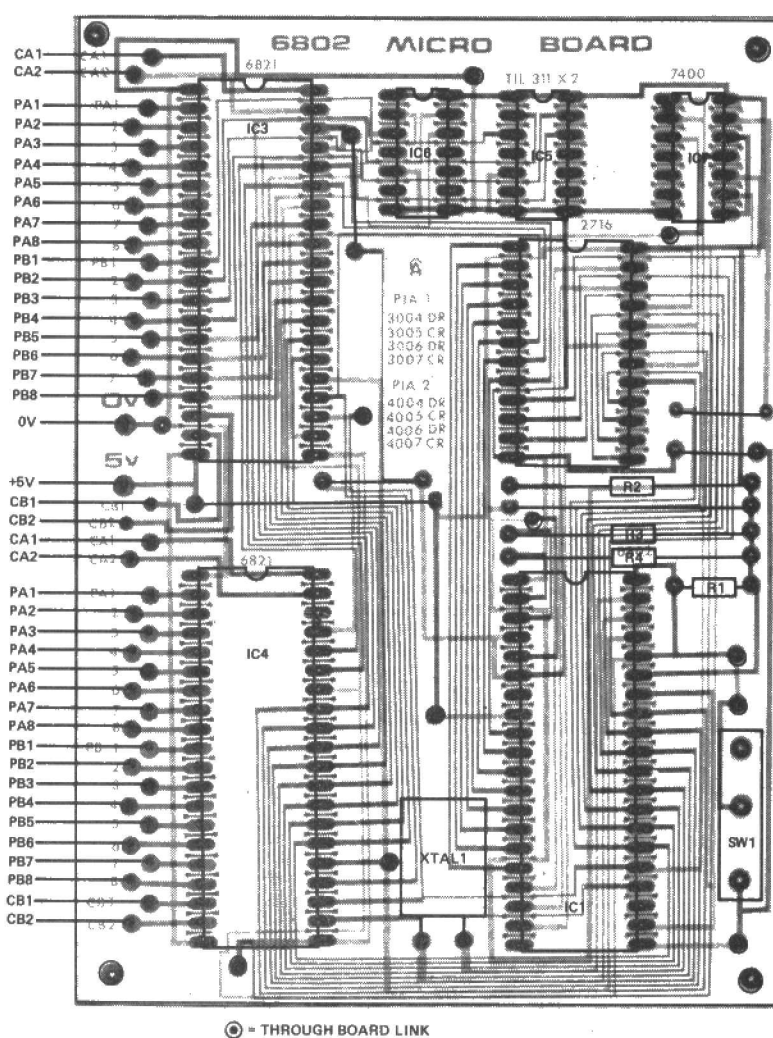


Fig. 6 Component overlay of the evaluation board.

lines CA1 and CA2 (CB1 and CB2 for the other side of PIA 1).

The addresses are well thought out in that, when the reset switch is operated, all the registers in the PIA are reset to zeros. This includes bit 2 in the control register. So the first time address 5004H is used, it will address the direction register. After this the programmer will ensure that bit 2 is set to 1, so that any further references to 5004H will address the data register. It is most unlikely that you will have to change the direction register contents in the same program but if so, it would be necessary to clear bit 2 first and reset it again afterwards.

As discussed earlier, I/O lines can be programmed as input or output in any configuration. For example if the direction register was initialised with 0000 1111, PA0-PA3 would be inputs and PA4-PA7 would be outputs. The register is available to the

programmer as address 5004H.

Once initialised, the data register is the one most used by the programmer and therefore has priority over the direction register which also shares memory address 5004H.

Unfortunately more has to be said about the control register flags. The main differences between sides A and B of the PIA are here and this is best shown in Fig. 8. Bit 2 has already been discussed, but every other bit in this register also has some effect upon the behaviour of the peri-

PIA 1 (IC3)			PIA 2 (IC4)		
SIDE A			SIDE A		
CONTROL	5005		CONTROL	4005	
DIRECTION	5004		DIRECTION	4004	
DATA	5004		DATA	4004	
SIDE B			SIDE B		
CONTROL	5007		CONTROL	4007	
DIRECTION	5006		DIRECTION	4006	
DATA	5006		DATA	4006	

Fig. 7 Register addresses on the evaluation board.

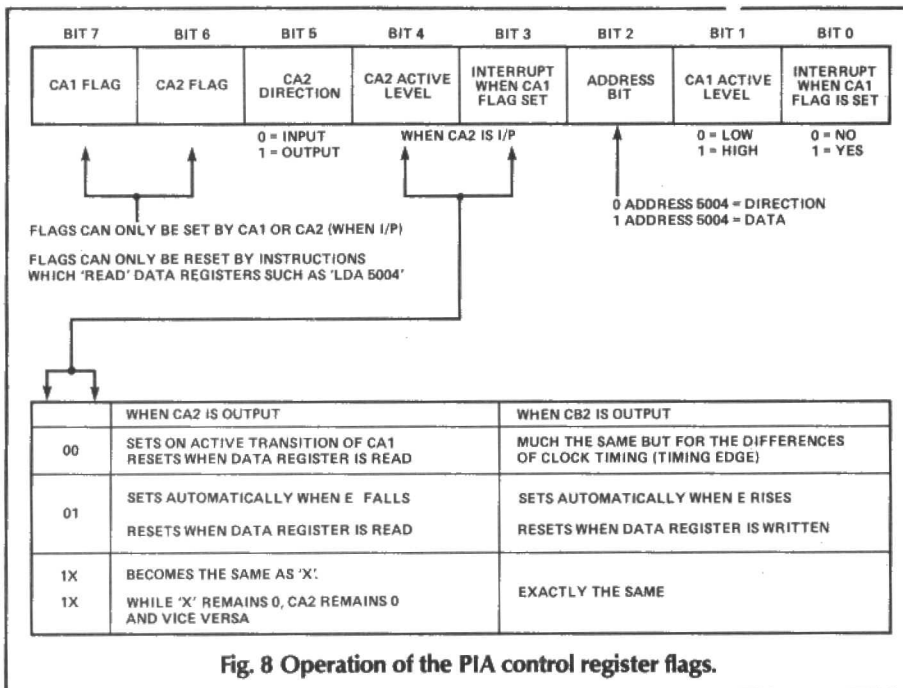


Fig. 8 Operation of the PIA control register flags.

To do this you will need either a programmed EPROM or an EPROM emulator. For those who do not already have one, an EPROM emulator design will be described in a follow-on article, but other emulators such as the one described in our July and August issues last year should be suitable. Constructors who do not have an emulator but do have access to an EPROM programmer and a UV eraser can simply load the test program onto a 2716 EPROM.

ADDRESS	PROGRAM
0000	8E 000F
0003	CD FF04
0006	FF 5006
0009	86 55
000B	B7 5006
000E	3F
07FE	80 RESET VECTOR
07FF	00 RESET VECTOR

Program 1

Program 1 is very simple and should cause the displays to show 55 when the reset switch is pushed. If this fails to work check the program. If it still does not work, check the signals described earlier with an oscilloscope. You need not worry about the complicated waveforms, just check that a switching signal is present or, in some cases, that the signal is held high.

Once this works you are ready to start writing your own programs.

Remember that complicated PIA, and note that it was initialised by two simple lines using the index register.

CE FF04  
FF 5006

In full this would be written quite differently using the accumulators

86FF LDA #FF  
B75006 STA 5006  
8604 LDA #04  
B75007 STA 5007

You can see how the 16 bit index register can simplify things. Overall program speed can be increased using this method, although it would be no advantage in the initialisation routine. It comes into its own in the subroutines.

In the example, the contents of the index register are said to be stored in location 5006H. You may

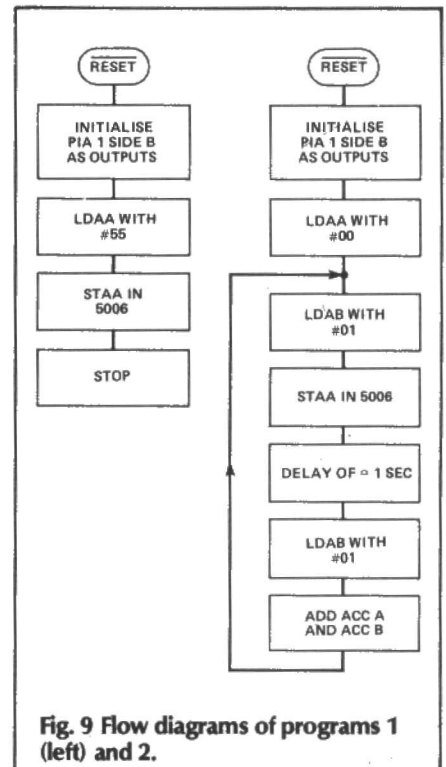


Fig. 9 Flow diagrams of programs 1 (left) and 2.

have thought this strange, trying to stuff 16 bits into 8. What the processor actually does is to store the least significant byte in 5007H and the most significant byte in location 5006H.

Because the programmer may like to be able to see a change on the displays, delays are a widely used subroutine. Again the 16 bit index register comes into use. An example of this is shown, giving a delay of around a second.

CE0000 LDX 0000  
09 DEX  
26FD BRE

This can be used in a program such as Program 2, which is a count sequence. This will cause the display to count up to FF before resetting to 00.

ADDRESS	PROGRAM
0000	8E 000F
0003	CE FF04
0006	FF 5006
0009	86 00
000B	C6 01
000D	B7 5006
0010	CE 0000
0013	09 FD
0014	26 01
0016	C6 01
0018	1B FO
0019	20 FO
07FE	80 00

Program 2

# UNIVERSAL EPROM PROGRAMMER MARK II

**Make programming even exotic EPROMs easy with our upgraded Universal EPROM programmer. Mike Bedford (hardware) and Gordon Bennett (software) produce a software-driven version of this invaluable device in both upgrade and self-contained form.**

**A**s far as the world of micro-electronics is concerned, a lot of water can pass under the bridge in 18 months. In August 1983, a design for a universal EPROM programmer was published in ETI and, as its name suggests, this piece of equipment allowed virtually all the common single supply EPROMs to be programmed. At this time the largest device available was the 27128, only preliminary data being available for the 27256. In the intervening period the 27256, 27512 and 27513 have become available and since they use a different programming voltage to the previous devices may not be programmed by the original programmer. The 2764A and 27128A have also made an appearance, these being lower programming voltage versions of the 2764 and 27128 respectively. This being the case, it seemed appropriate to introduce a MkII version of the EPROM programmer to support these new devices and at the same time make some other improvements. We have produced an upgrade board to allow existing users of the MkI board to enhance it and also a single MkII board for those without the earlier board.

The MkII Universal EPROM Programmer is capable of pro-

gramming a comprehensive range of single supply EPROMs varying in size from the 2758 to the 27512 and 27513 and including the 27-series, 25-series and the Motorola 68-series as well as a number of EEPROMs. In addition it allows the 2764 and larger devices to be programmed by the intelligent programming method hence reducing programming times drastically. All supply voltages have been made switchable under program controls so there is no need for a switch on the programming console. Two LEDs have been provided to indicate the current status of the programmer — in particular whether or not it is safe to remove the device. A modification to speed up EPROM reading has been made and, as a final enhancement, it is easier to set up since the adjustment of the programming voltages has been made much finer and the potentiometers are now more accessible when the board is rack-mounted.

In both versions, the programmer is fully programmable and everything is controlled by software. It is designed around the Tanbus specification which means that it should be an easy task to interface it to any 6502 or 6809 based system and users of a

Tangerine computer will be able to plug the programmer directly into the system rack.

### **New Devices**

Before describing the new programmer it is helpful to outline the advances in the realm of EPROMs which have made this upgrade necessary. Table 1 shows the pin-outs of all the devices which are supported. A similar illustration was included with the original article showing how standard pin-outs made designing a *universal* programmer relatively easy. The new devices conform to the same standard and also have JEDEC pin-outs.

This family of devices must now include the largest single page EPROMs which will be used with 8-bit processors, as the capacity of a 27512 is 64K bytes — in other words, it occupies the entire memory map of an 8-bit system. The 27513 has the same capacity as the 27512 but the memory is organised differently having 4 pages of 16K bytes each and therefore representing the first of a new class of devices — paged EPROMs. To specify the page to be accessed a write operation is performed. The least significant 2 bits of the following data word

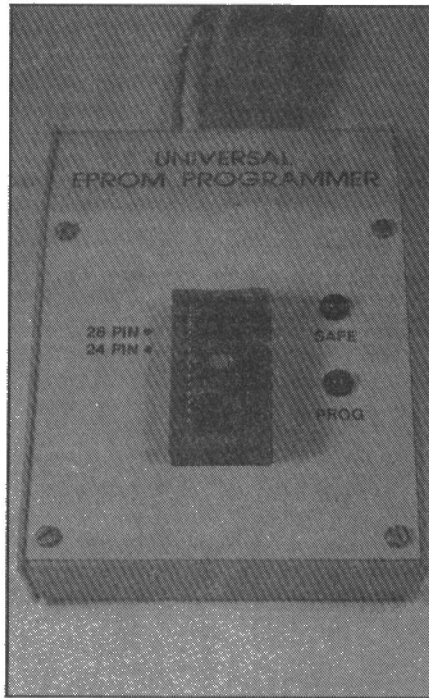


then specify the page number.

The major fact about the 27256 and 27512/2513 which makes them incompatible with the original EPROM programmer is that the programming voltage is 12.5V. This follows the trend of decreasing programming voltages as the capacity increases and the silicon die size decreases, the devices up to and including the 2732 using 25V and the 2764 and 27128 using 21V. In addition, versions of the 2764 and 27128 which also use the new 12.5V Vpp have been released. These are known as the M2764A and 27128A.

Intelligent programming is possible on all devices from the 2764 upwards. In this case, 1ms programming pulses are applied to the EPROM until it verifies, at which point a further pulse is applied. This contrasts with the standard programming method in which a 50ms programming pulse is always used. As the larger EPROMs are introduced, intelligent programming becomes increasingly desirable. It can reduce programming times from almost one hour to about eight minutes for the 27512.

Intelligent programming requires the supply voltage to be raised from the normal 5V to 6V during the programming cycle, a facility not available on the Mk1 board. A different programming time reduction method has been introduced on the latest version of the Texas 25 series devices and on some manufacturers' recent 2732s and 2764s. These devices use a fixed length programming pulse of 10mS rather than the



The console of the programmer.

standard 50mS pulse.

Another facility introduced on some of the newer devices is referred to as 'intelligent identifier' or 'auto select mode'. After applying +12V to A9, where this facility is available, one of two bytes may be read out depending on the logic level of A0. These two bytes contain codes identifying both the device type and the manufacturer. It was decided not to implement this mode for two reasons. Firstly, the facility was designed for industrial production programming where the process is often carried out by those with a minimal knowledge of electronics. By contrast, the home user will probably

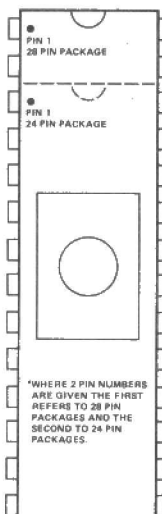
be clear about what device type is being used. Secondly, not all devices include the facility, and it is reasonable to assume that applying +12V to A9 of EPROMs without intelligent identifier will be detrimental. In an environment in which all devices from the 2758 upwards are to be programmed, the provision of the feature will increase the likelihood of destroying EPROMs.

The price of EPROMs has been influenced by the fact that quartz windows could only be fitted in ceramic packages. Recent advances now allow a seal to be made between quartz and plastic and, as a result, some manufacturers are releasing EPROMs in plastic packages at a significant cost reduction. Over the past few years, the price of EPROMs has already reduced to the point where they are comparable to the price of ROMs. Since a large proportion of the remaining cost is due to the quartz window, manufacturers have also started producing EPROMs without the quartz window at an even lower price.

The lack of quartz window means that these devices cannot be exposed to ultra violet and erased. They are referred to as production EPROMs or OTP EPROMs (One Time Programmable). Since these EPROMs are electrically identical to standard EPROMs, they are programmed in exactly the same way.

Some EPROMs are now available not only in the standard 24 or 28 pin DIL (dual-in-line) packages but also in the newer, smaller, LCC (leadless-chip-carrier) packages which have pins spaced at

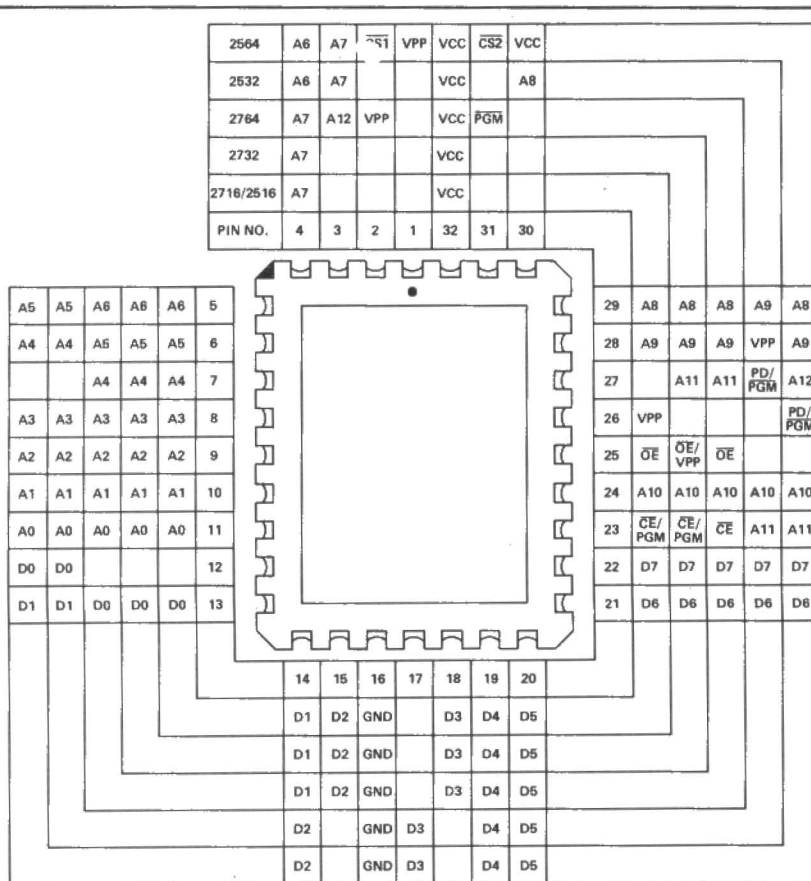
27513	27512	27256	27128	27128A	2564	2764	68764	2632	2732	68732	2716	2758	*PIN NO.
N/C	A15	VPP	VPP	VPP	VPP								1
A12	A12	A12	A12	CS1	A12								2
A7	A7	A7	A7	A7	A7	A7	A7	A7	A7	A7	A7	A7	3/1
A6	A6	A6	A6	A6	A6	A6	A6	A6	A6	A6	A6	A6	4/2
A5	A5	A5	A5	A5	A5	A5	A5	A5	A5	A5	A5	A5	5/3
A4	A4	A4	A4	A4	A4	A4	A4	A4	A4	A4	A4	A4	6/4
A3	A3	A3	A3	A3	A3	A3	A3	A3	A3	A3	A3	A3	7/5
A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	8/6
A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	9/7
A0	A0	A0	A0	A0	A0	A0	A0	A0	A0	A0	A0	A0	10/8
D0	D0	D0	D0	D0	D0	D0	D0	D0	D0	D0	D0	D0	11/9
D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	12/10
D2	D2	D2	D2	D2	D2	D2	D2	D2	D2	D2	D2	D2	13/11
GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	14/12



*PIN NO.	2758	2716	68732	2732	2532	68764	2764	2564	27128	27256	27512	27513
28							VCC	VCC	VCC	VCC	VCC	VCC
27							PGM	CS2	PGM	A14	A14	WE
26/24	VCC	VCC	VCC	VCC	VCC	VCC	N/C	N/C	A13	A13	A13	A13
25/23	A8	A8	A8	A8	A8	A8	A8	A8	A8	A8	A8	A8
24/22	A9	A9	A9	A9	A9	A9	A9	A9	A9	A9	A9	A9
23/21	VPP	VPP	AR	A11	VPP	A12	A11	A12	A11	A11	A11	A11
22/20	OE	OE	E/VPP	OE/VPP	PD/PGM	E/VPP	OE	PD/PGM	OE	OE	OE/VPP	OE/VPP
21/19	AR	A10	A10	A10	A10	A10	A10	A10	A10	A10	A10	A10
20/18	CE/PGM	CE/PGM	A11	CE/PGM	A11	A11	CE	A11	CE	CE	CE/PGM	CE
19/17	D7	D7	D7	D7	D7	D7	D7	D7	D7	D7	D7	D7
18/16	D6	D6	D6	D6	D6	D6	D6	D6	D6	D6	D6	D6
17/15	D5	D5	D5	D5	D5	D5	D5	D5	D5	D5	D5	D5
16/14	D4	D4	D4	D4	D4	D4	D4	D4	D4	D4	D4	D4
15/13	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3	D3

Table 1 Pin-outs of all devices supported by the programmer.

# PROJECT: EPROM Programmer MkII



**Table 2 Pin-outs of all LCC devices which could be supported by the programmer.**

0.05" on 4 sides of a rectangle and so allow a much greater PCB packing density. Internally these devices are identical to conventionally packaged EPROMs and as a result the programming requirements are the same. To handle them, the EPROM programmer only needs to be provided with a different socket on the console. Table 2 shows the pin-out of those devices currently available in this package. It should be noted that the 25 series devices differ from each other and the 27 series devices in this configuration more than in the standard DIL package. Accordingly, it would be advisable to consider programming only the 27 series EPROMs in LCC configuration or to provide a number of different sockets.

## Similar Devices

The term EPROM is usually taken to mean UV erasable PROM, but there is a closely related family of devices — electrically erasable programmable read-only memories, known as EEPROMs or E<sup>2</sup>PROMs. At the time of designing the original programmer, the extra complexity involved in supporting EEPROMs

was not considered justifiable in view of their high cost. The price of EEPROMs has not dropped drastically and they are, therefore, still quite rare among home computer users. But numerous enhancements to these devices have been made which simplify the programming and accordingly they may be supported by the MkII programmer.

The fact which complicated the programming of the original Intel 2816 (2K x 8 EEPROM) was the fact that it used a 21V programming voltage which had to be shaped by an RC circuit to give an exponential rise. The next development still used 21V for programming but the waveform shaping requirement was relaxed, the only restriction then being on the fall time of the Vpp pulse. The latest EEPROMs don't even require a high programming voltage, internal circuitry generating this from the +5V supply. In addition, there are now some devices which support these very latest programming techniques but are compatible with earlier devices, accepting either 21V or TTL programming levels.

EEPROMs have also developed in the method of programming.

On the first devices, a byte could only be programmed if it were first erased, either by writing an FF(HEX) to that byte or by using the complete chip erase facility. On the more recent devices, bytes may be directly re-programmed without the need for erasing first. Programming times and the number of programming cycles have also seen improvements. The first 2816 required 10mS programming pulses whereas some of the newer versions will programme in 2mS per byte. The technology used in EEPROMs, HMOS-E FLOTEX cell design, has an inherent limitation on the number of programming cycles. The original EEPROMs had a lifetime of 10,000 cycles but 1 million cycles is now not uncommonly quoted.

Unfortunately, there isn't the same degree of standardisation among EEPROMs as with UV EPROMs. Although a 2816 is always a 2K x 8 EEPROM, different manufacturers' devices with this number may represent a number of different points within the progression outlined above. In addition 2816A, 2817, 2817A and 5213 are variations on the same theme by various manufacturers. Because of these complications, we won't give a list of EEPROM type numbers which are supported by the MkII Universal EPROM programmer. It will, in fact, handle all those 2K x 8 devices which feature TTL level programming. Some 8K x 8 EEPROMs are also becoming available — for example, the 2864 and 52B33. Where these are programmed by TTL levels, they may also be supported by the MkII programmer.

## Mark II Board — Hardware

This section refers to either the MkII EPROM programmer or the MkI with the addition of the upgrade board, the hardware of these two configurations being identical with one exception. The MkI board has 4 x 6821 PIAs, of which 2 are used by the programmer for control functions leaving 2 free for general use. The MkII board utilises 3 PIAs for controlling the programmer, the 4th having been omitted in order to fit the extra circuitry onto the PCB. The upgrade board makes use of the 3rd PIA on the MkI board but does not, however, affect the 4th one which means that this configuration gives a spare PIA, the true MkII board not having this facility. (See 'How It Works' for part

numbering.)

Table 3 is a memory map of the MkII Universal EPROM Programmer in which the function of each bit is outlined. Some bits control certain functions such as Vcc and Vpp voltage levels, the majority, however, control the signal levels on various pins of SK3, the EPROM socket. For all bits connected to SK3, except those marked Vcc or Vpp, writing a 1 will set the pin to a logic high, whereas writing a 0 will set it to a logic low. For the Vcc and Vpp bits, a 1 sets the pin to the currently selected Vcc or Vpp voltage and a 0 sets the pin to 0V. It will be noticed that some pins have more than one bit controlling

them. This happens where a particular pin can take either a logic level or a Vpp voltage. In such cases, although this wouldn't normally be required, it would not be harmful to set both bits high at the same time since the two corresponding outputs are isolated by use of diodes.

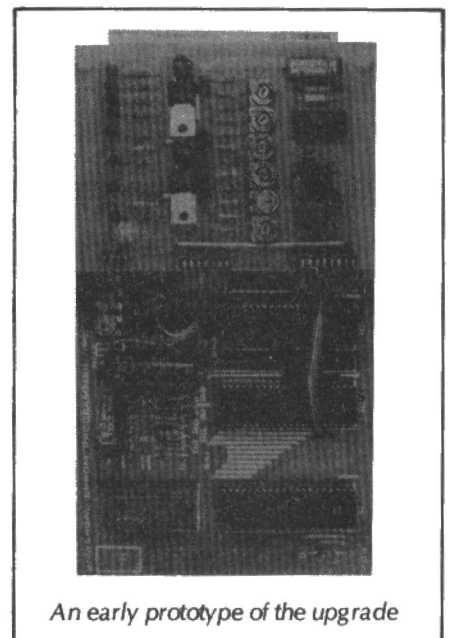
Finally, in the 6821 PIA, the data direction registers are double addressed with the corresponding I/O port register. Bit 2 in the appropriate control register determines which of these two registers actually will be addressed, a 1 selecting the I/O port register and a 0 selecting the data direction register. Once the data direction

register is selected, setting a 1 to a bit in this register selects the corresponding bit in the I/O port to be an output whereas a 0 selects the I/O port bit to be an input.

## The Upgrade Board — Construction

Construction of the upgrade board for the MkI programmer is straightforward and no special comments need to be made. Interfacing to the main board and setting up do require explanation. The procedure is as follows:

- Remove the regulator IC10 from the main board. This may be re-used as IC12 or IC13 on the upgrade board.
- Remove R4, R5 and C1 from the main board. RV1, RV2, RV3, Q3, Q4 and R6 may also be removed if required.
- Remove SW1 if fitted to the main PCB or if not fitted remove the two wire links in its place.
- Remove D1 on the main board.
- Add D3 to the main board, connecting the cathode to SK3 pin 1 and the anode to IC9 pin 9.
- Replace C5 (10n) by 100n on the main board.
- Physically fix the upgrade board to the main board by use of three plastic bolts. If the fixing holes marked on the upgrade board are used they will align with 'track-free' areas of the main board. The photographs with this article illustrate the means of interconnection.
- Make the connections between the two boards as shown in Table 4.



An early prototype of the upgrade

IC NUMBER	REGISTER	ADDRESS OFFSET	DATA DIRECTION	BIT DESIGNATIONS											
				7	6	5	4	3	2	1	0				
IC9	PORT A/ DATA DIRECTION REGISTER A	0	OUTPUT	1 A15	UNUSED	UNUSED	2 A12 or CS1	23 A11 or A12	21 A10	24 A9	25 A8				
				CA2 UNUSED				SELECT REGISTER AT ADDRESS 0 0-DATA DIRN A 1-PORT A		CA1 UNUSED					
IC9	PORT B/ DATA DIRECTION REGISTER B	2	OUTPUT	3 A7	4 A6	5 A5	6 A4	7 A3	8 A2	9 A1	10 A0				
				SET TO 1 TO MAKE CB2 OUTPUT		SET TO 1 TO MAKE CB2 OUTPUT		26 A13 or VCC	SELECT REGISTER AT ADDRESS 2 0-DATA DIRN B 1-PORT B		CB1 UNUSED				
IC8	PORT A/ DATA DIRECTION REGISTER A	4	OUTPUT/ INPUT	19 D7	18 D6	17 D5	16 D4	15 D3	13 D2	12 D1	11 D0				
				CA2 UNUSED				SELECT REGISTER AT ADDRESS 4 0-DATA DIRN A 1-PORT A		CA1 UNUSED					
IC8	PORT B/ DATA DIRECTION REGISTER B	6	OUTPUT	VCC +5V SELECT (NOT (VCC+5V) = VCC +5V SELECT	VPP +12V5 SELECT	VPP +21V SELECT	VPP +5V SELECT	23 VPP	22 VPP	27 R10, CS2, A14	20 A11 or CE				
				NOT (VPP+5V AND NOT (VPP+12V5) AND NOT (VPP+21V) - VPP+26V SELECT				SELECT REGISTER AT ADDRESS 6 0-DATA DIRN B 1-PORT B		CB1 UNUSED					
IC8	CONTROL REGISTER B	7	—	CB2 UNUSED				SELECT REGISTER AT ADDRESS 8 0-DATA DIRN B 1-PORT B		CB1 UNUSED					
				UNUSED BY EPROM PROGRAMMER AVAILABLE FOR GENERAL USE VIA SK2 (ON MK1 BOARD)											
IC7	PORT A/ DATA DIRECTION REGISTER A	8	—	UNUSED BY EPROM PROGRAMMER AVAILABLE FOR GENERAL USE VIA SK2 (ON MK1 BOARD)											
				UNUSED BY EPROM PROGRAMMER AVAILABLE FOR GENERAL USE VIA SK2 (ON MK1 BOARD)											
IC7	PORT B/ DATA DIRECTION REGISTER B	A	OUTPUT	UNUSED	UNUSED	UNUSED	22 OE	RED LED ON	GREEN LED ON	28 VCC	1 VPP				
				CB2 UNUSED				SELECT REGISTER AT ADDRESS A 0-DATA DIRN B 1-PORT B		CB1 UNUSED					

NOTE:  
IN CASES WHERE MORE THAN 1 FUNCTION IS GIVEN FOR  
A PARTICULAR BIT THE ACTUAL FUNCTION DEPENDS ON  
WHICH DEVICE TYPE IS BEING USED. DETAILS MAY BE  
FOUND IN FIGURE 1.

Table 3 Memory map of the programmer.

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Table 3 Memory map of the programmer.



# PROJECT: EPROM Programmer MkII

J. If using a programming console remove the switch, connecting the two wires which this interrupted directly to the appropriate ZIF socket pins and add 1 green and 1 red LED which are wired to connector A on the upgrade board via a 4-way cable as follows:

- A/1 Green LED anode
- A/2 Green LED cathode
- A/3 Red LED anode
- A/4 Red LED cathode

K. Installation is now complete and Vcc and Vpp voltages need to be set up as follows after first temporarily removing the wires to connector C:

1. Apply +5V to C7 only and adjust RV4 to give +5V on B4.
2. Apply +5V to C6 only and adjust RV5 to give +12.5V on B4.
3. Apply +5V to C5 only and adjust RV6 to give +21V on B4.
4. Remove +5V from C5 and adjust RV7 to give +25V on B4.
3. Apply +5V to C4 only and adjust RV8 to give +5V on B2.
4. Remove +5V from C4 and adjust RV9 to give +26V on B2.

## UPGRADE BOARD CONNECTOR

C/ 1  
C/ 2  
C/ 3  
C/ 4  
C/ 5  
C/ 6  
C/ 7  
C/ 8  
C/ 9  
C/10  
B/ 1  
B/ 2  
B/ 3  
B/ 4  
B/ 5  
B/ 6  
B/ 7  
B/ 8

## MAIN BOARD DESTINATION

IC7 PIN 14  
IC7 PIN 13  
IC7 PIN 12  
IC8 PIN 17  
IC8 PIN 15  
IC8 PIN 16  
IC8 PIN 14  
IC7 PIN 11  
IC7 PIN 10  
IC8 PIN 12  
IC11 PIN 1  
NO CONNECTION  
SK3 PIN 28  
O/P (CENTRE) OF IC10  
SK3 PIN 1  
OV (IC11 PIN 11)  
SK3 PIN 22  
+5V (IC11 PIN 13)

Table 4 Connections between the upgrade board and the original programmer.

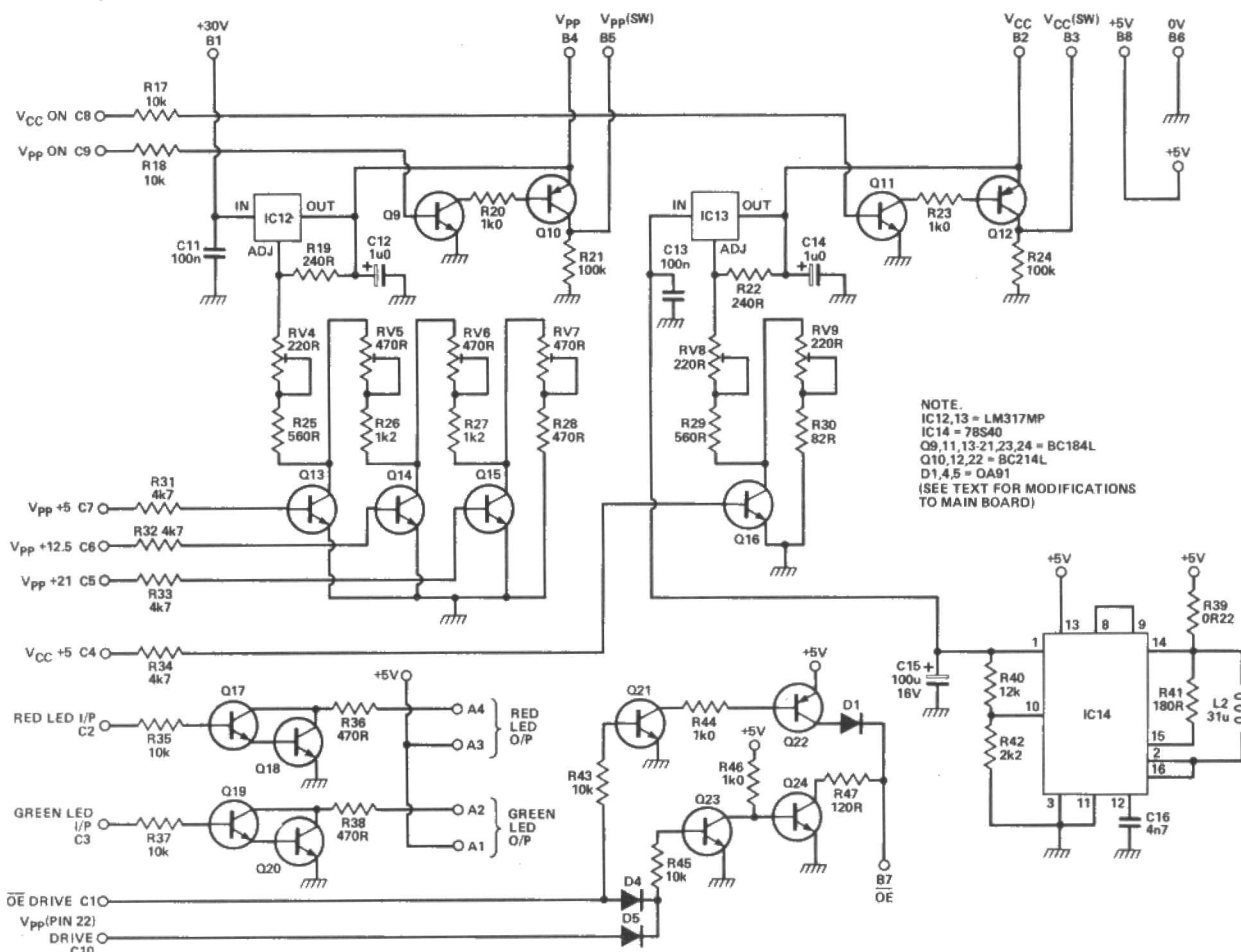
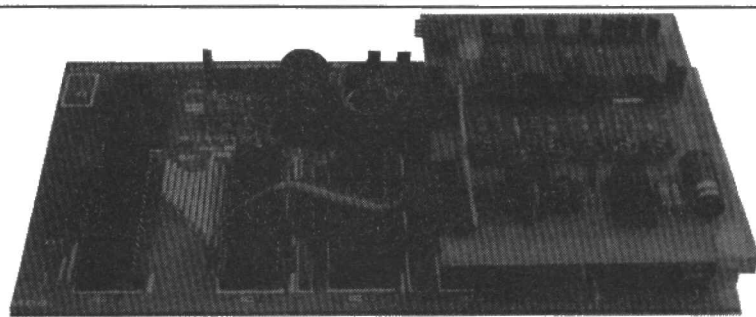


Fig. 1 Circuit diagram of the upgrade board (note component numbering).

# PROJECT: EPROM Programmer MkII

## HOW IT WORKS

Readers should note that the component numbers on Fig. 1 — the upgrade board circuit diagram — do not start at 1. Instead they follow on from the component numbers on the main MkI board. The following description assumes a knowledge of the workings of the MkI board to which the upgrade board is connected and a description of which may be found in ETI August 1983.

The upgrade board supplies Vpp (selectable to +5V, +12.5V, +21V or +25V), Vcc (selectable to +5V or +6V), a replacement driver for OE (the active low output enable line) and drivers for two LEDs. The old part of the Vpp circuitry which generates an unregulated +30V by use of a 78S40 has been retained. However, the regulator consisting of a LM317MP and a resistor chain, in which portions of the chain could be switched out by transistors, has been replaced. The new regulator is similar to the one on the MkI board but differs in two respects. Firstly each variable resistor in the chain has a fixed resistor in series with it, hence giving a more accurate means of setting up the voltages. Secondly an extra resistor portion and transistor have been added to allow the +12.5V programming voltage to be selected. This regulation circuit comprises IC12, Q13, Q14, Q15 and the associated passive components. An unswitched Vpp is passed to various Vpp switches on the main board. Transistors Q9 and Q10 provide a switched Vpp which replaces the supply to EPROM pin 1, previously switched manually. IC14 and its associated components form a second step-up circuit providing a +8V supply which is regulated to either +5V or +6V for Vcc. This regulator circuit is built around IC13 and is a similar configuration to the Vpp regulator. Transis-

tors Q11 and Q12 provide a switched Vcc supply which replaces the original, manually switched supply to EPROM pin 28.

It should be noted that the Vcc supply to pin 24 on the EPROM need not come from this circuitry as no 24pin devices feature intelligent programming, so +5V will always be used.

On the original board a 10nF capacitor, C5, was connected between OE/Vpp on pin 22 of the EPROM socket and 0V. This was a compromise between the 100nF suppression capacitor actually specified in the 2732 data sheet and a value which wouldn't slow down logic edges too much. On the new circuit the recommended 100nF capacitor is used but logic signals are not significantly slowed down as a result of the Q21/Q22 combination which provides a high current OE signal capable of charging the capacitor rapidly and Q24 which provides a logic low signal bypassing the suppression capacitor. Capacitor C5 should be changed on the original board.

Transistor Q23 provides a NOR function, turning Q24 on when neither of the signals driving EPROM pin 22 are present.

Transistors Q17, Q18, Q19 and Q20 simply form two darlington drivers with built-in current limiting resistors to drive two LEDs indicating programmer status. In addition to the extra circuitry on the upgrade board an extra diode, D3, is added to the main board. This is to provide the extra address line A15 to pin 1 of the EPROM socket, the diode being required to isolate it from the Vpp supply which can also be present on this pin. This diode — an OA91 — should be fitted between SK3 pin 1 (cathode) and IC9 pin 9 (anode).

## PARTS LIST

### RESISTORS (all 1/4W, 5% unless stated)

R17, 18, 35, 37, 43, 45	10k
R19, 22	240R
R20, 23, 44, 46	1k0
R21, 24	100k
R25, 29	560R
R26, 27	1k2
R28, 36, 38	470R
R30	82R
R31, 32, 33, 34	4k7
R39	OR22 W/W
R40	12k
R42	2k2
R47	120R 1/2W
RV4, 8, 9	220R vertical min preset
RV5, 6, 7	470R vertical min preset

### CAPACITORS

C5 (replace on main board)	100n ceramic
C11, 13	100n ceramic
C12, 14	1u tantalum
C15	100u 16V axial electrolytic
C16	4n7 polyester

### SEMICONDUCTORS

IC12, 13	LM317 MP
IC14	78S40
Q9, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24	BC184L
Q10, 12, 22	BC214L
D1, D4, D5	OA91
D3 (fit on main board)	OA91

### MISCELLANEOUS

L2	31uH, 13 turns 22 SWG on RM6 pot core (AL=250)
Connectors A, B, C	0.1" pitch right angled molex connectors, 4, 9 and 8 ways respectively.
PCB	three plastic bolts and nuts for attaching to main PCB.

## BUY LINES

All components are standard. The biggest problem may be in finding a 28-pin ZIF socket. These are supplied by Watford Electronics and Technomatic. Electrovalue and Maplin will supply a OR22 wirewound resistor and Electrovalue will also supply the RM6 pot cores. The Molex connectors are standard inter-PCB connectors and the Euro connector for the MkII board likewise. The version of the LM317 you should look for is one in a TO 202 or TO 220 case — a 317 MP or 317 T will do if you can't find a 317 MP. All semiconductors should be available from any supplier with a good stock — Technomatic, Rapid and TK advertise the LM317 T, Watford advertises all the other ICs.

Over the next two months, we'll be dealing with an entirely self-contained version of the MkII and with the software to drive the upgrade.

ETI

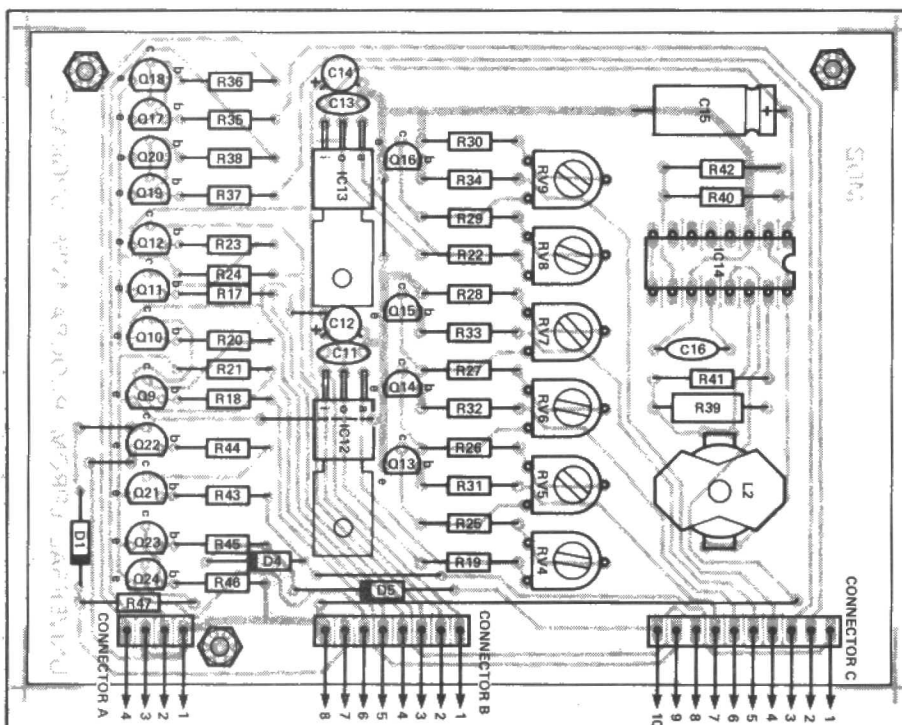


Fig. 2 Overlay diagram of the upgrade board.

# LARGE DIGIT SCOREBOARD

Do your achievements go unnoticed? Build Ken Wood's big, bright display board and make sure that everyone knows the score.

This scoreboard has been designed for use in a gymnasium or other large space and uses mains light bulbs to provide a display which is large enough to be seen from a distance and bright enough to be read easily in daylight. The scores or other numerical information are normally entered via thumbwheel switches but the system could also be adapted to accept data from a microcomputer. The basic model has a four digit display which could be used, for example, to show a two-digit score for each of two teams, but the number of digits can easily be increased to suit other applications.

## The Circuit

The heart of the project is a digit driver module. This uses a 7447A (BCD to seven segment decoder) to drive a digit composed of mains lamps via seven triacs. The BCD information is fed serially through a shift register, and picked off the drive the display.

One module is used per digit in the display, and they are chained together so that they form a long shift register of four bits per digit. The control logic is isolated from the mains by an opto-isolator module at the start of the chain, and only one of these is needed for the display.

The third module is a power supply. This provides two separate 5V supplies, one for the circuitry in the display drivers and the other for circuitry isolated from the mains by the opto-isolator module. The supplies shown only offer up to 100mA, so for displays with a lot of digits a different regulator may be needed.

Finally, there is a controller module. This takes data from up to

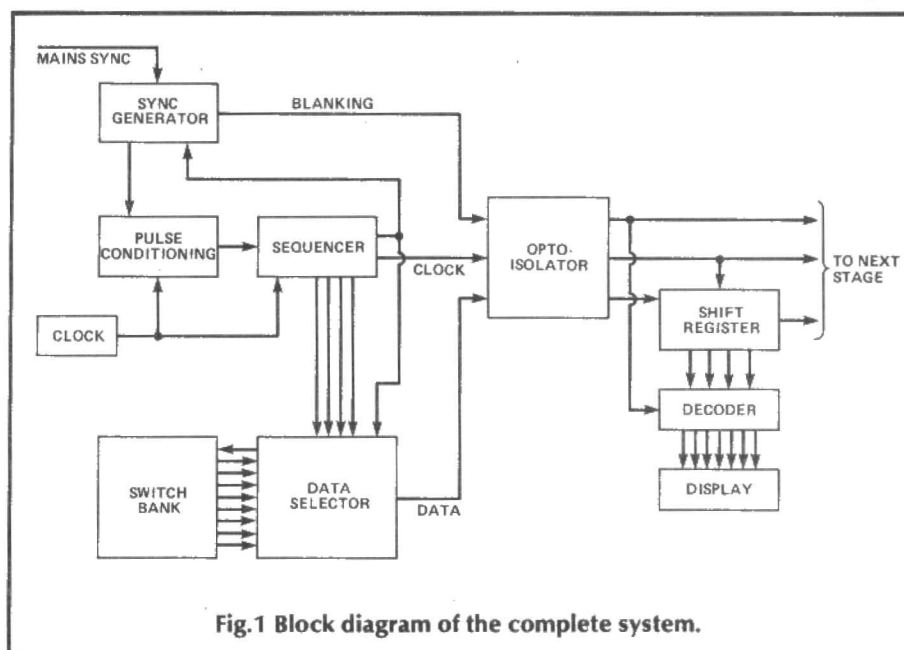
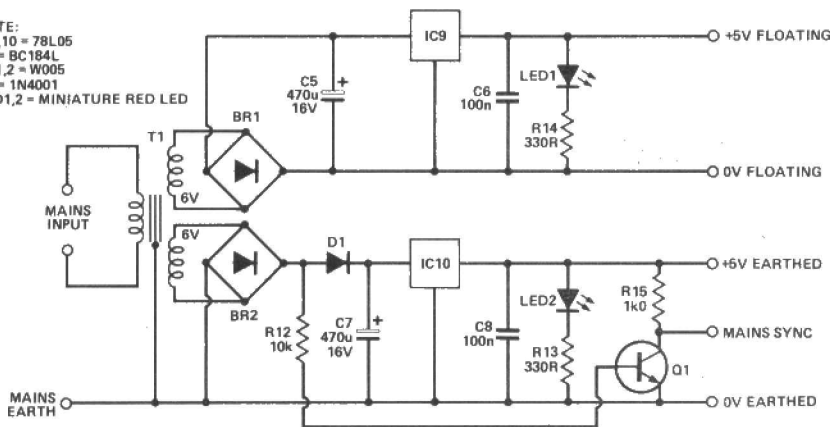


Fig.1 Block diagram of the complete system.



## HOW IT WORKS

NOTE:  
IC9,10 = 78L05  
Q1 = BC184L  
BR1,2 = W005  
D1 = 1N4001  
LED1,2 = MINIATURE RED LED



The power supply is in two sections, each of which has a bridge rectifier and a smoothing capacitor followed by a voltage regulator (ICs 9 & 10). C6 and C8 cut out any high frequency spikes and protect the regulators from oscillation. Each section is also fitted with a LED and current limiting resistor as a visual check of operation.

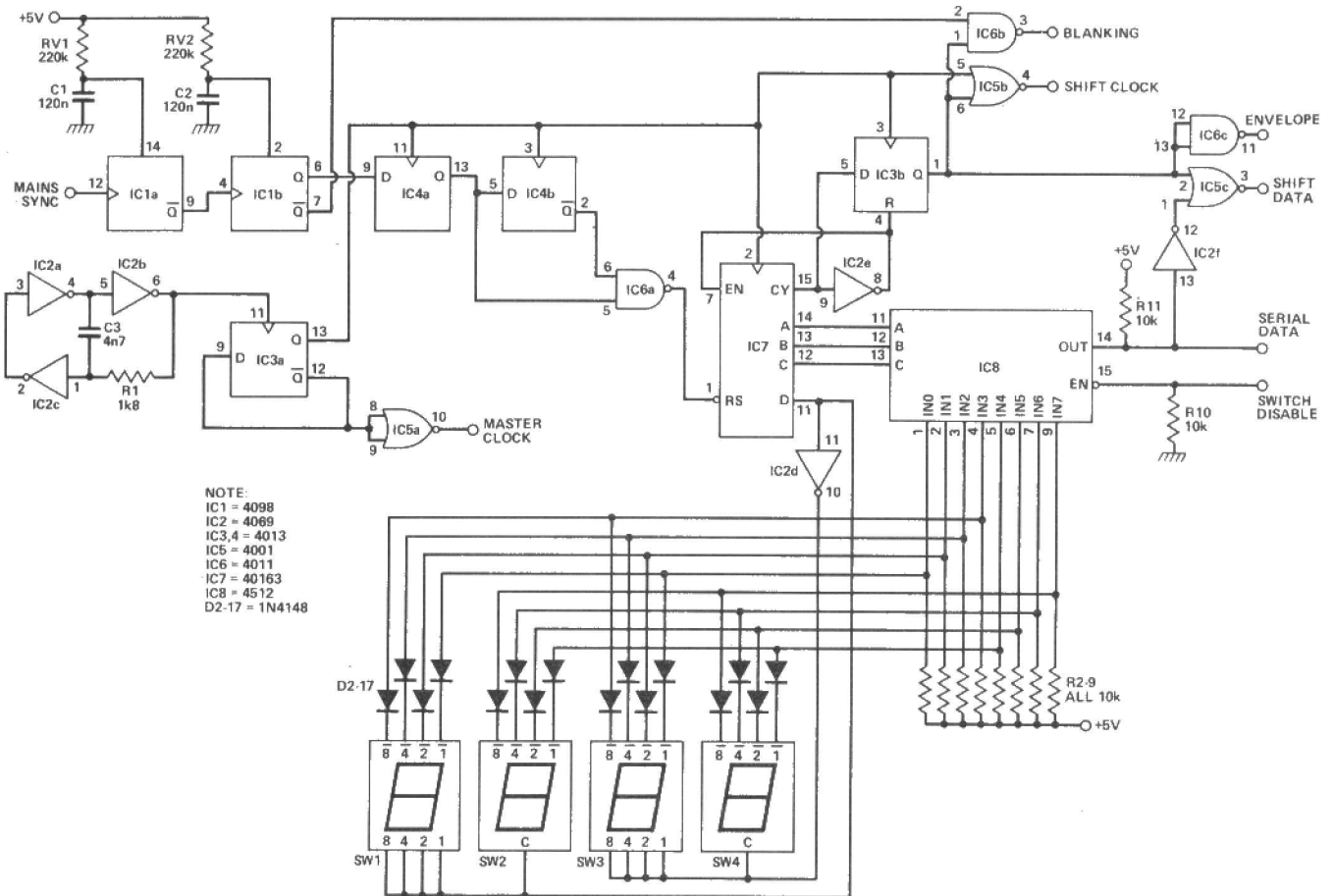
The section that supplies power to the control electronics has its 0V connected to earth as a safety precaution, and also provides mains sync pulses to the controller module. The bridge rectifier BR2 is isolated from the smoothing capacitor with a diode D1, so a full wave rectified AC waveform appears at the junction between D1 and R12. This is fed

to TR1, which is driven hard on for all but the brief interval when the waveform is at less than 0.7V, 100 times a second.

The mains sync pulses are not necessarily at the zero crossing point of the mains because of the phase shifts that can occur through the transformer. To overcome this, they are fed into a monostable IC1a which is trimmed so that its output is truly at the mains zero crossing point. This is fed into a second monostable whose output is gated with the controller blanking output to hold the triacs off for a period into the mains half cycle. This achieves the dimming function.

IC2a, 2b, 2c, and 3a produce a square wave clock at about 50kHz. It is also used to control the operation of the remainder of the module.

IC4a, 4b, and 6a produce a pulse lasting for exactly one clock period at each mains crossing. This is used to reset IC7, a four bit counter. The counter controls IC8, an eight input multiplexer, to sequence through the bit inputs from the thumbwheel switches. Output D from the counter selects one switch bank or the other via IC2d.



NOTE:  
IC1 = 4098  
IC2 = 4069  
IC3,4 = 4013  
IC5 = 4001  
IC6 = 4011  
IC7 = 40163  
IC8 = 4512  
D2-17 = 1N4148

Figures 2, 3, 4 and 5. Circuit diagrams of the power supply (top left), the controller (above), the opto-isolators (above right) and the digit driver board. Note the use of separate earthed and floating +5V supplies, the controller being operated from the earthed supply, and bear in mind that one digit driver board is required for each digit of the display.

# PROJECT : Scoreboard

When the counter reaches 15 the carry output goes high and the counter is inhibited via IC2e. This means that, after each mains zero crossing, the data bits from the thumbwheel switches appear in turn at the serial data output and via IC2f and 5c at the shift data output to the digit drivers.

The beginning and end of this sequence is detected by IC3b which produces an envelope signal while data is coming out of the controller. The signal is made available to an external controller via IC6, and also gates the shift data and shift clock outputs to the digit drivers. It is also fed into the blanking signal so that, even with a very short period set for the monostable IC1b, the triacs cannot come on while data is being transmitted.

The three control signals connected to the digit drivers are fed through an opto-isolator circuit to prevent any mains potentials reaching the control circuits, hence making the unit completely safe for connection to, for example, a home

computer.

Each of the three channels is identical, so reference will be made to one channel only. An emitter follower transistor Q2 drives the LED in the opto-isolator IC11. The opto-isolator transistor, biased by R19 to improve its high frequency response, is buffered by a Schmitt trigger (IC14a & R25), and a final output buffer IC14b drives the output.

IC15 is a four bit shift register, which converts the serial data to parallel at its outputs. The fourth output passes serial data on to the next driver module in the chain, thus with four digit drivers each gets its new data after sixteen clocks. The parallel BCD data is decoded by IC16 to form the segment drive to each of seven triacs.

The blanking signal drives Q5 which switches off the outputs of IC16, preventing the possibility of a digit being displayed while the shifting process goes on and allowing the display to be dimmed.

four BCD thumbwheel switches and turns it into a serial stream to send to the display drivers. It also takes mains zero crossing pulses from the power supply and uses them to time the serial transmission. This allows the display data to be updated while the displays are off at the zero crossing point of the AC mains cycle.

The controller also provides connections so that the display can be driven by a special purpose external controller, or by a simple I/O port on a home computer. In the case of a display with more than four digits, this is probably the easiest way to enter data and the circuitry for the thumbwheel switches can be omitted.

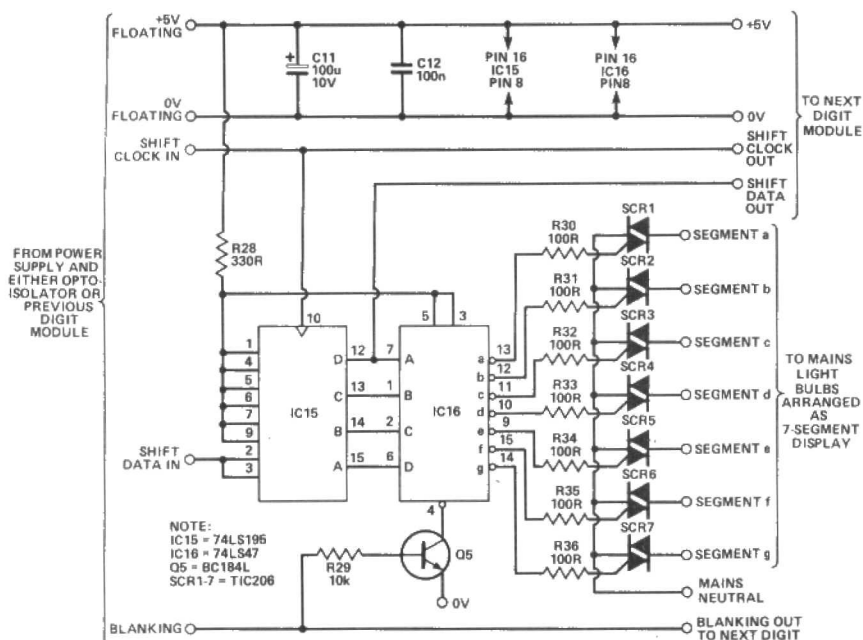
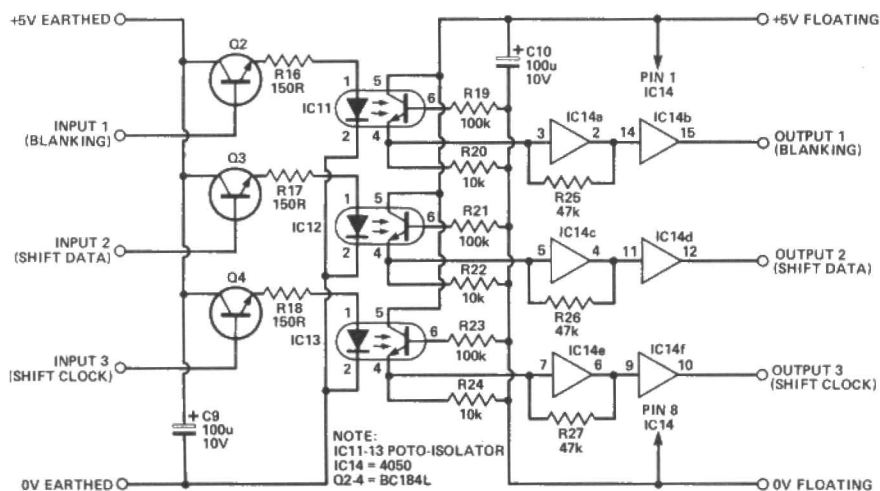
## Construction

The box should be built first, and this is probably the most difficult part of the construction for those who are not naturally good at carpentry. It is not possible to give exact details and dimensions because these will vary according to the size of the digits and the number required, but the arrangement used in the prototype is shown in Fig. 6 and may be useful as a guide. Note the downward tilt of the display area which makes for easy viewing from below, and the steel brackets used to support a coloured plastic filter in front of the lamps.

The circuit boards are all single

## BUYLINES

The BCD thumbwheel switches used in the prototype were obtained from RS Components, who will not supply parts to non-trade customers. If you cannot find another source you will either have to persuade a friendly local radio dealer to order them for you or, for a small surcharge, order them through Crewe-Allan & Company, 51 Scrutton Street, London EC2. The transformer came from Maplin, who can also supply suitable opto-couplers. Other suppliers may also stock these parts but check carefully that the transformer dimensions suit the PCB layout. Maplin also stock sheet aluminium which could be cut up to form the heatsink and the control panel, but you may find that a local hardware shop can supply panels cut to size. The semiconductors are all readily available, with the exception of the 4098 and possibly the 40163. Cricklewood and Maplin stock the 4098 and Watford stock all of the semiconductors. The PCBs are available from our PCB service, and don't forget that you will need one digit driver board for each digit of your display.



## PARTS LIST CASE AND CONTROL PANEL

D2-17	1N4148
FS1	panel-mounting fuse holder and 3A fuselink
LP1	panel-mounting mains neon
SK1	7-pin DIN socket or other multipole connector to choice
SW1-4	BCD ten position thumbwheel switch with true and inverse outputs
SW5	DPST toggle or other mains on-off switch

mains lights bulbs and batten lampholders as required; wood, brackets, etc, for enclosure; coloured filter for front of display; small aluminium panel for the controls and nuts and bolts to mount; cable ties or spiral wrap or similar; stand-off pillars, nuts and bolts for mounting PCBs; ribbon cable, writing, etc.

sided except for the controller which is double sided. The legs of the components on the controller board are used to bridge between tracks on each side of the board, so in places the components must be soldered on the top side of the board as well as underneath. This rules out the use of sockets for the ICs.

Printed circuit board pins are used for the flying lead connections to the power supply (except the mains into the transformer), the isolator module, and the

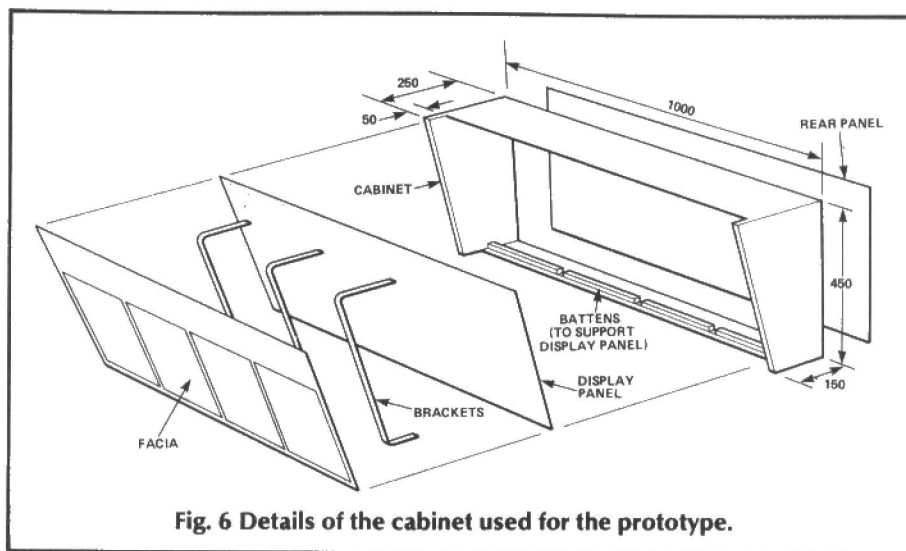


Fig. 6 Details of the cabinet used for the prototype.

display drivers (except for the triac-to-lamp connections). The pins should be installed first, followed by the wire links, the resistors, the capacitors, and the semiconductors. Be careful with the ICs as some of them are CMOS. Leave the power supply transformer until last and do not fit the triacs for the time being.

The triacs on the digit driver modules are mounted with a small heatsink sandwiched between them and the board. This is a length of aluminium strip, details of which are shown in Fig. 9. The heatsink also provides the extra two mounting points for the board. Each triac is bolted to the board through the heatsink with a mica washer and bush to insulate the tab. Silicone grease should be used between the tab and the aluminium to improve heatflow.

Two of the pins on each triac are

## PARTS LIST POWER SUPPLY

### RESISTORS (all 1/4W 5%).

R12	10k
R13,14	330R
R15	1k

### CAPACITORS

C5,7	470u 16V radial electrolytic
C6,8	100n 5% polycarbonate

### SEMICONDUCTORS

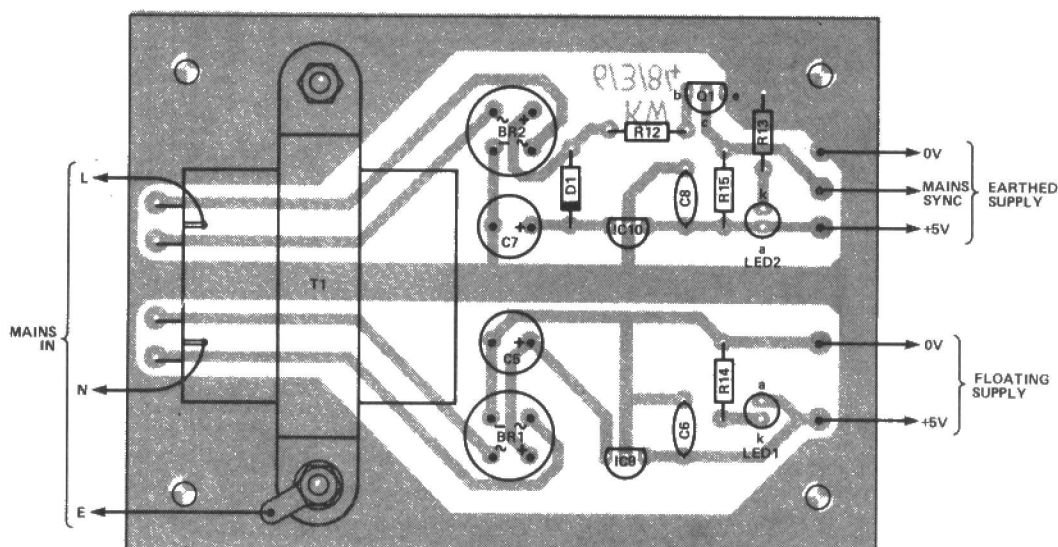
IC9,10	78L05
Q1	BC184L
D1	1N4001
BR1,2	W005
LED1,2	miniature red LED

### MISCELLANEOUS

T1	6-0-6V, 500mA mains transformer, chassis mounting
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PCB; 1mm terminal pins; earth tag; nuts and bolts for mounting transformer.

Fig. 7 Component overlay of the power supply board. Note the earth connection to the frame of the transformer and the mains connections taken directly to the transformer, not to the PCB.





# PROJECT : Scoreboard

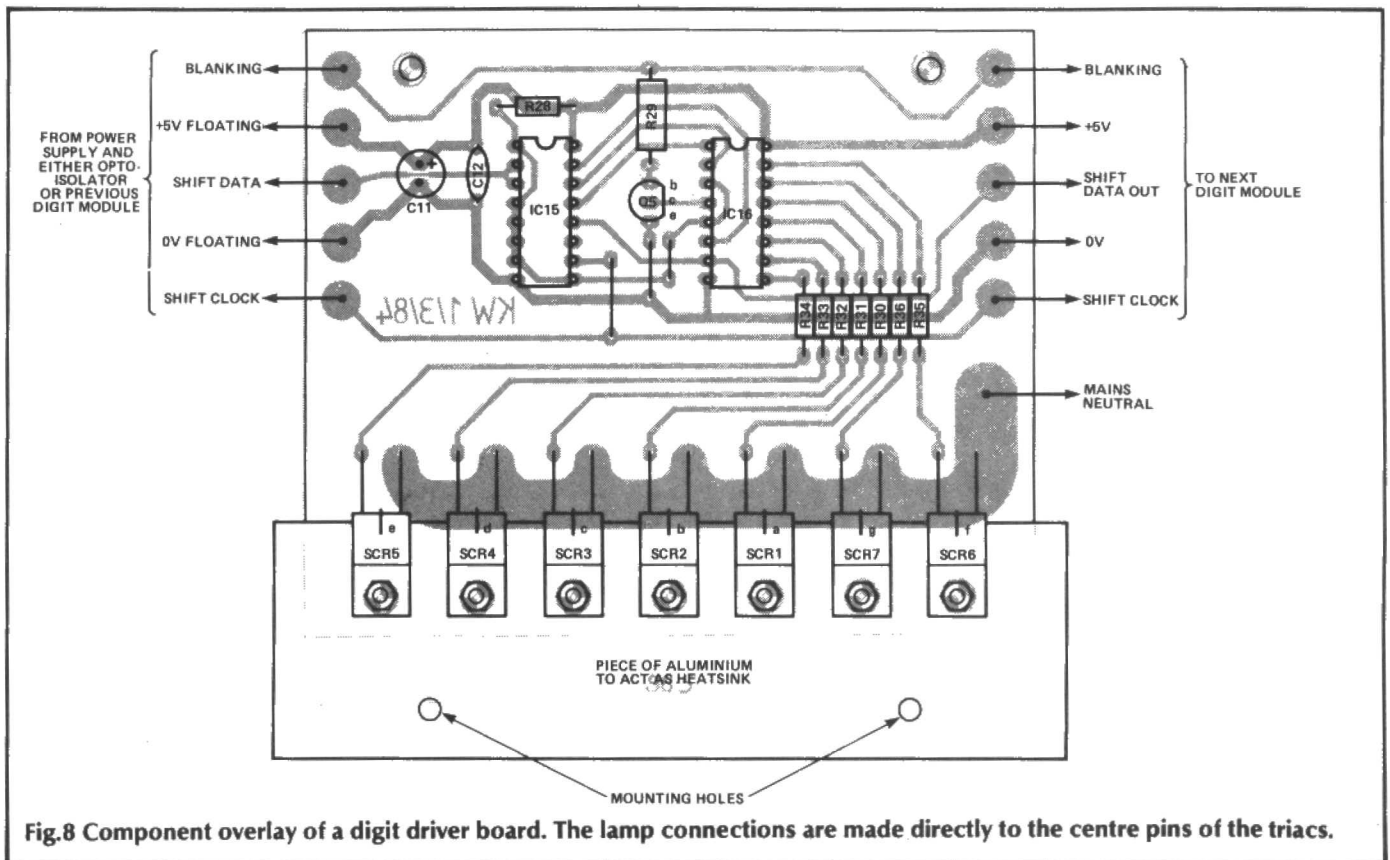


Fig.8 Component overlay of a digit driver board. The lamp connections are made directly to the centre pins of the triacs.

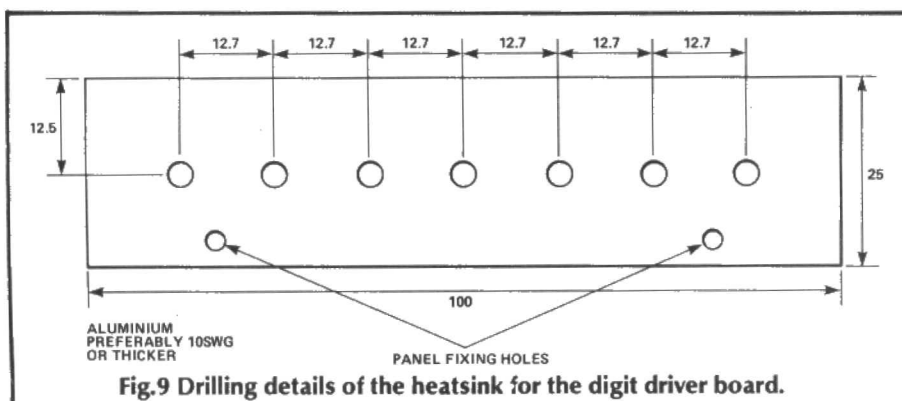


Fig.9 Drilling details of the heatsink for the digit driver board.

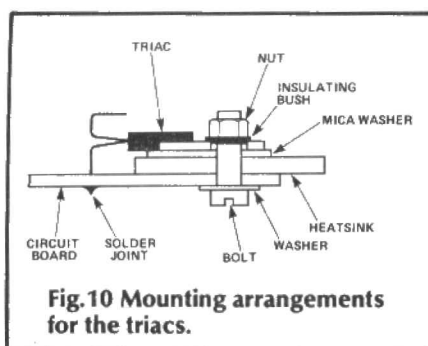


Fig.10 Mounting arrangements for the triacs.

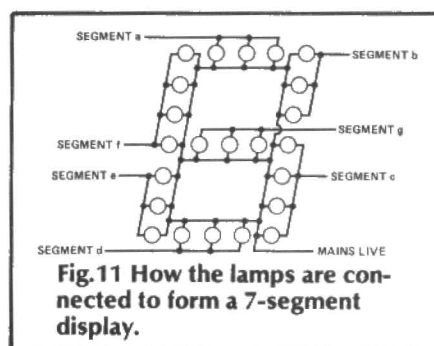


Fig.11 How the lamps are connected to form a 7-segment display.

bent down to pass through the board, while the centre pin is bent up for a flying lead connection to the lamps. Only after the triac-heatsink assembly has been completed should the triacs be soldered to the board.

The displays themselves are pygmy bulbs in bulb holders, mounted on a wooden panel. 15W bulbs should give sufficient light for most applications. Three bulbs are used for each segment as shown in figure 11, but for larger

## PARTS LIST DIGIT DRIVER MODULE

### RESISTORS (all 1/4W 5%)

R28	330R
R29	10k
R30-36	100R

### CAPACITORS

C11	100u 10V radial electrolytic
C12	100n poly-carbonate

### SEMICONDUCTORS

Q5	BC184L
IC15	74LS195
IC16	74LS47
SCR1-7	TIC206

### MISCELLANEOUS

PCB; 1mm terminal pins; nuts and bolts, mica washers and insulating bushes for triacs; heatsink (see text and Buylines); IC sockets if desired — 2 off 16 pin DIL.

displays it might be better to use the small incandescent strip lamps commonly found in bedside lights for each segment.

The reverse of the lamp panel is used as a chassis, and the various circuit boards are screwed onto it through standoff pillars. Interwiring is kept neat by using spiral wrap around the cable

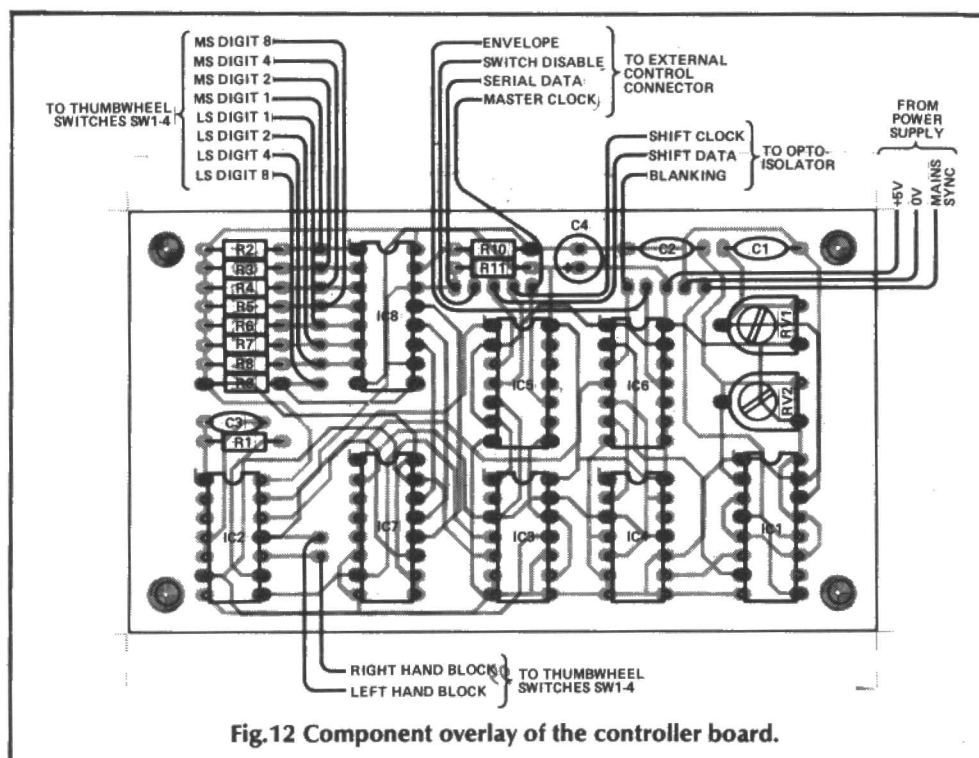


Fig.12 Component overlay of the controller board.

## PARTS LIST — CONTROLLER MODULE

<b>RESISTORS (all 1/4W 5%)</b>		C3	4n7 5% poly-carbonate	IC5	4001
R1	1k8			IC6	4011
R2-11	10k	C4	22u 25V radial electrolytic	IC7	40163
RV1,2	220k miniature horizontal preset			IC8	4512
<b>ACITORS</b>		<b>SEMICONDUCTORS</b>		<b>MISCELLANEOUS</b>	
C1,2	120n 5% poly-carbonate	IC1	4098	PCB	
		IC2	4069		
		IC3,4	4013		

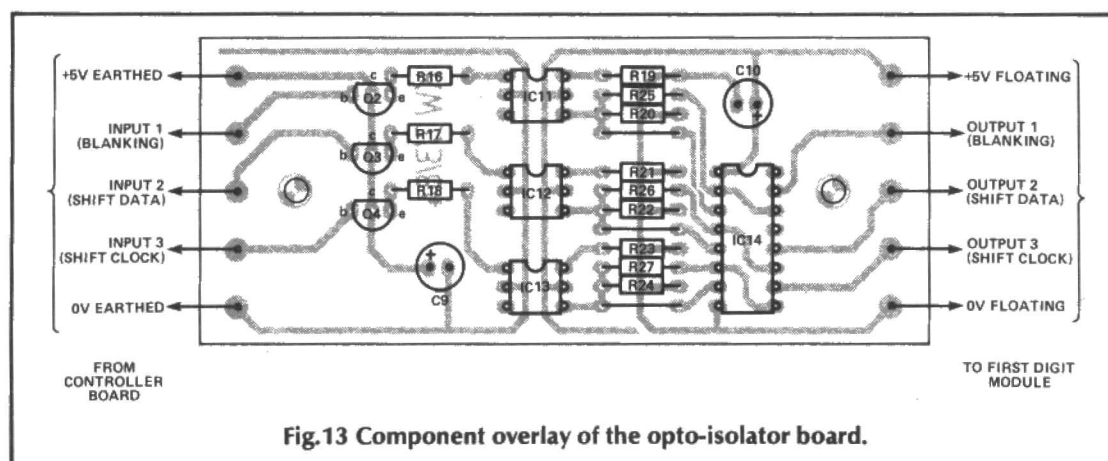


Fig.13 Component overlay of the opto-isolator board.

## PARTS LIST — ISOLATOR MODULE

<b>RESISTORS (all 1/4W 5%)</b>		<b>CAPACITORS</b>			
R16-18	150R	C9,10	100u 10V radial electrolytic	IC14	4050
R19,21,23	100k	<b>SEMICONDUCTORS</b>		<b>MISCELLANEOUS</b>	
R20,22,24	10k	Q2-4	BC184L	PCB; 1mm terminal pins; IC socket if desired — 1 off 16 pin DIL.	
R25-27	47k	IC11-13	Opto-isolator (see Buylines)		

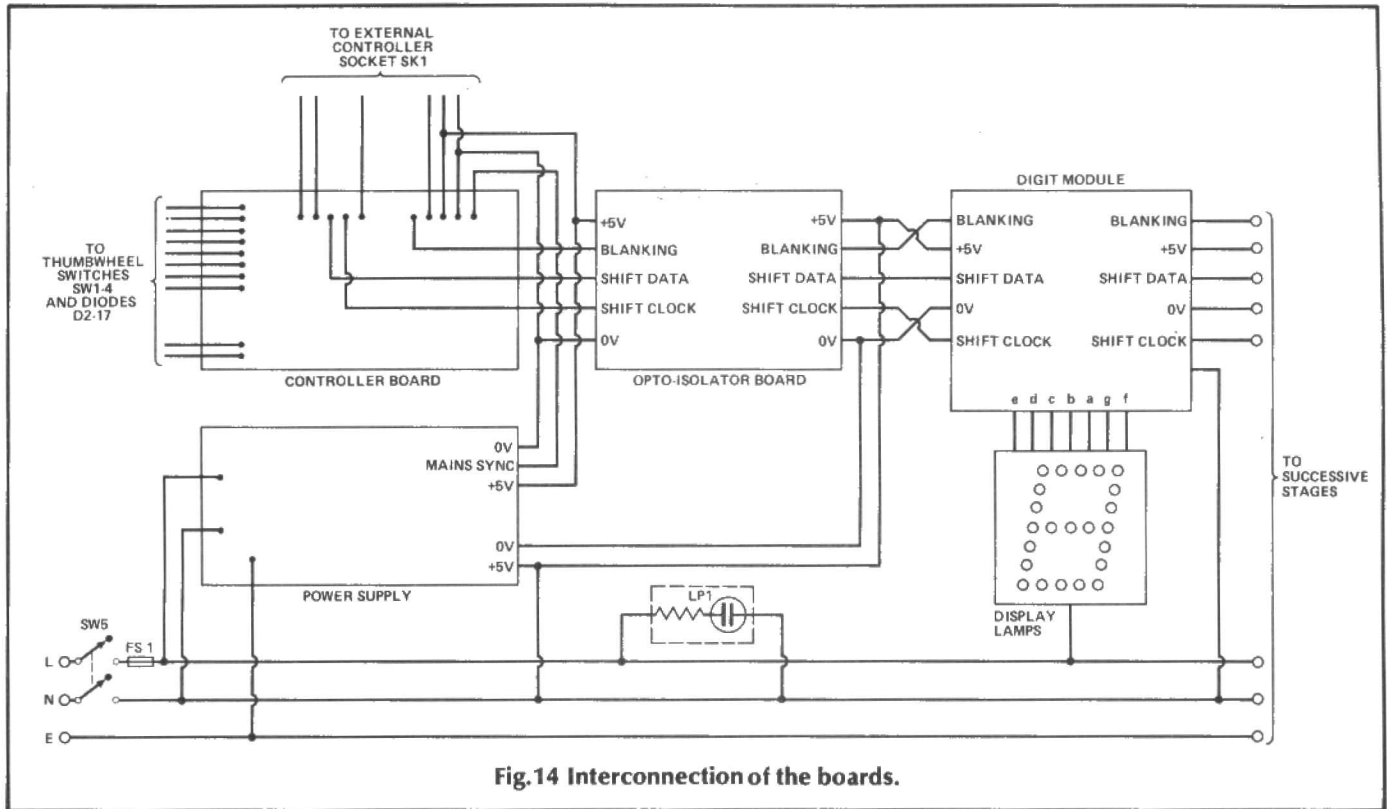


Fig. 14 Interconnection of the boards.

looms, or ribbon cable as appropriate. Make sure that suitable cable is used for the mains supply to the lamps, between the lamps and the triacs, and the returns from the digit driver boards.

The supply, return, and earth wires have been taken individually to a central supply point, rather than chaining them from one point to the next. This includes the power supply module as well as each display. Remember that much of the wiring carries mains voltages and currents, and must be of a high standard to avoid the risk of accidents.

The diodes associated with the thumbwheel switches are mounted on the switches themselves, and the arrangement shown uses the inverse data outputs. If the switches used do not have inverse outputs, turn all the diodes round, swap the common connections for the two pairs of digits and alter the pull-up resistors on the controller module so that they pull down to 0V. If a display of less than four digits is required, simply omit switches and diodes starting with SW1, then SW2, etc.

Any convenient connector can be used for the outlet to the external controller. A seven pin DIN socket has been used in the prototype. The external controller can interrogate the thumbwheel

switches by intercepting the serial data and control signals. It can inject data in place of the switch data by driving the switch disable input to a logic "1" (anything over 3.7V), at which point the output of IC8 goes high impedance and can be driven externally.

If the switch inputs are never going to be used, the controller module may be dedicated to external control by omitting IC4, 7, and 8, and R2-R9. The copper track on the component side of the board leading to IC3 pin 1 should be cut (close to the IC as it also goes to other places) and a wire link soldered between the pad of IC8 pin 15 and IC5 pin 2. This allows the external controller to generate the envelope signal. IC6 pins 5 and 6, and IC3 pins 4 and 5 must be wired to 0V to protect their CMOS inputs.

## Setting Up and Use

It is a good confidence booster if the power supply works when you switch it on. Try it with its outputs disconnected, and the LEDs should light to show that something is getting through. If you have a meter, check that both outputs are producing 5V.

Unfortunately, very little intermediate checking can be performed on the rest of the circuit. Be careful when poking around the digit driver areas as these are

live when the mains is connected.

Make the set up adjustments with a single bulb plugged in somewhere, and arrange for the display to show all "8"s. Set RV1 on the controller module fully anticlockwise and RV2 fully clockwise. Switch on, and the lamp should be at full brightness. Using an insulated screwdriver so that mains hum pickup does not affect adjustments, slowly turn RV1 clockwise until the lamp suddenly goes dim, and stop there. Now turn RV2 anticlockwise, and the lamp should increase in brightness. The lamp may be set to the desired operating brightness, remembering that the cooler a lamp is run, the longer it will last.

If the display is to be run at full brightness, either because you need that much light or because you wish to keep RF interferences to a minimum, continue to turn RV2 anticlockwise until the lamp suddenly goes out then turn it back to the point where the lamp comes on again.

The display is now ready for use, so switch off and install all the lamps. It would be as well to have a few spare triacs in stock, because when bulbs blow they tend to take their triacs with them. Running the display at reduced brightness should help a little.



# STEREO SIMULATOR

Live up your mono recordings, give breadth to your stereo with this unit developed by the indefatigable Dave Bradshaw from an idea by B. Webb.

There are many occasions when you're stuck with a mono signal, but it seems a waste. Mono is particularly irritating when you're using stereo headphones - it feels as if everything is coming just from the exact centre of your head. Here's a little unit that can remove that irritation.

Let's get one point perfectly straight, though. When you're presented with a mono signal, there's no way that you can get a true stereo signal back again. There are complex processes available to synthesise an apparent stereo signal, but these are very costly and time consuming and are primarily of use in the recording studio.

So, what the circuit does here is a bit of sleight of hand. By introducing phase and amplitude differences between the two channels, a semblance of

ambience can be generated, and this can remove the more objectionable effects of listening to mono through a stereo medium. However, the unit described here does not restore the stereo information.

As a bonus, the unit can also be used to generate spatial stereo. In this, each channel is intermixed with the other channel out of phase. In theory, this expands the stereo image. In practice, the degree of success depends very strongly on the material being listened to. The effect can make the results from headphones rather more comfortable, so you might like to try out the spatial stereo as well as the pseudo variety.

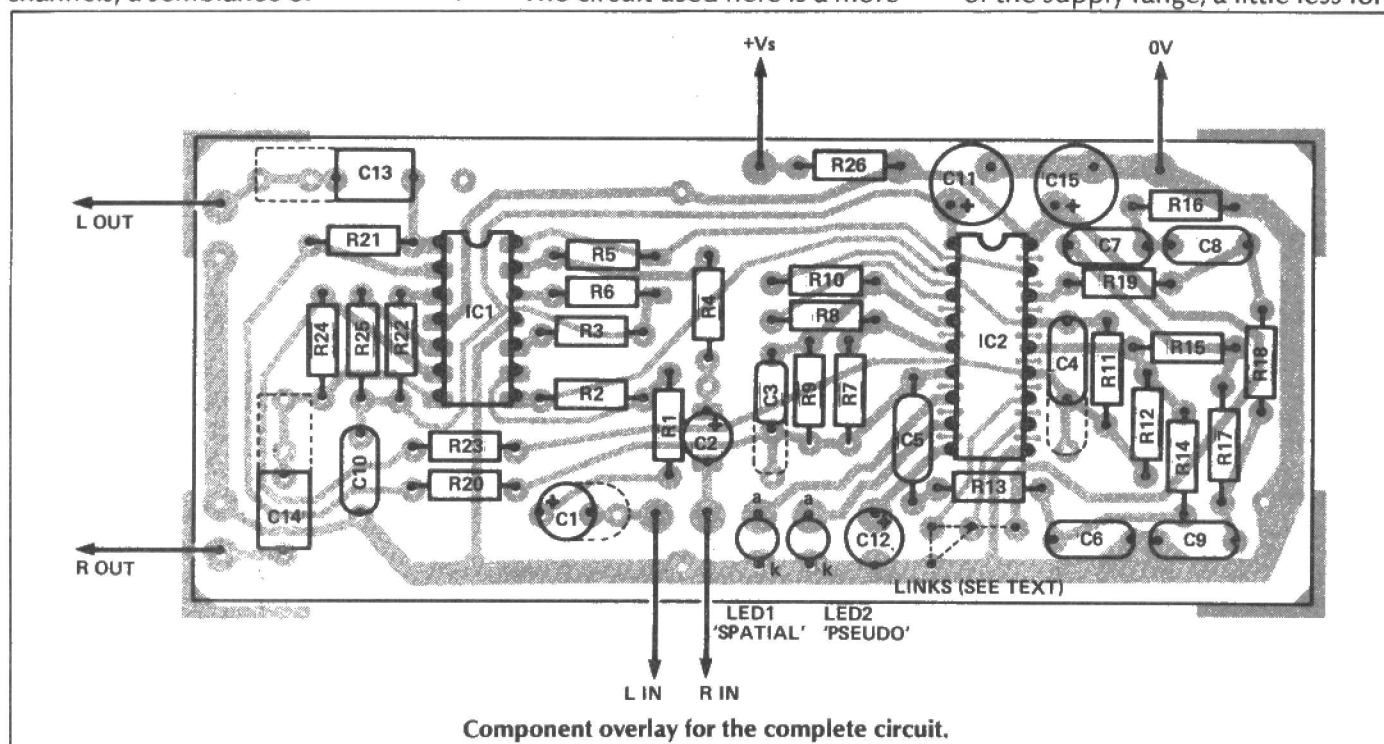
## The Circuit

The circuit used here is a more-

or-less direct 'lift' of the circuit in Mullard's application notes. The TDA3810 is a purpose-made device for pseudo and super stereo, so why reinvent the wheel?

To the special IC has been added a quad op-amp, to boost the signal to the level required for optimum noise performance, and to reduce and buffer the signal after the TDA3810. In the parts list, we specify a TL094, but any quad op-amp can be used provided there is sufficient supply voltage for it - it so happens that the TL094 can operate down to 4.5 V, which is the minimum supply voltage for the TDA3810. Maximum supply voltage for the 3810 is 16.5V, which is below the maximum for the TL094.

Supply current will be in the region of 10 mA (without the LEDs), a little more to the top end of the supply range, a little less for



Component overlay for the complete circuit.

# PROJECT: Stereo Simulator

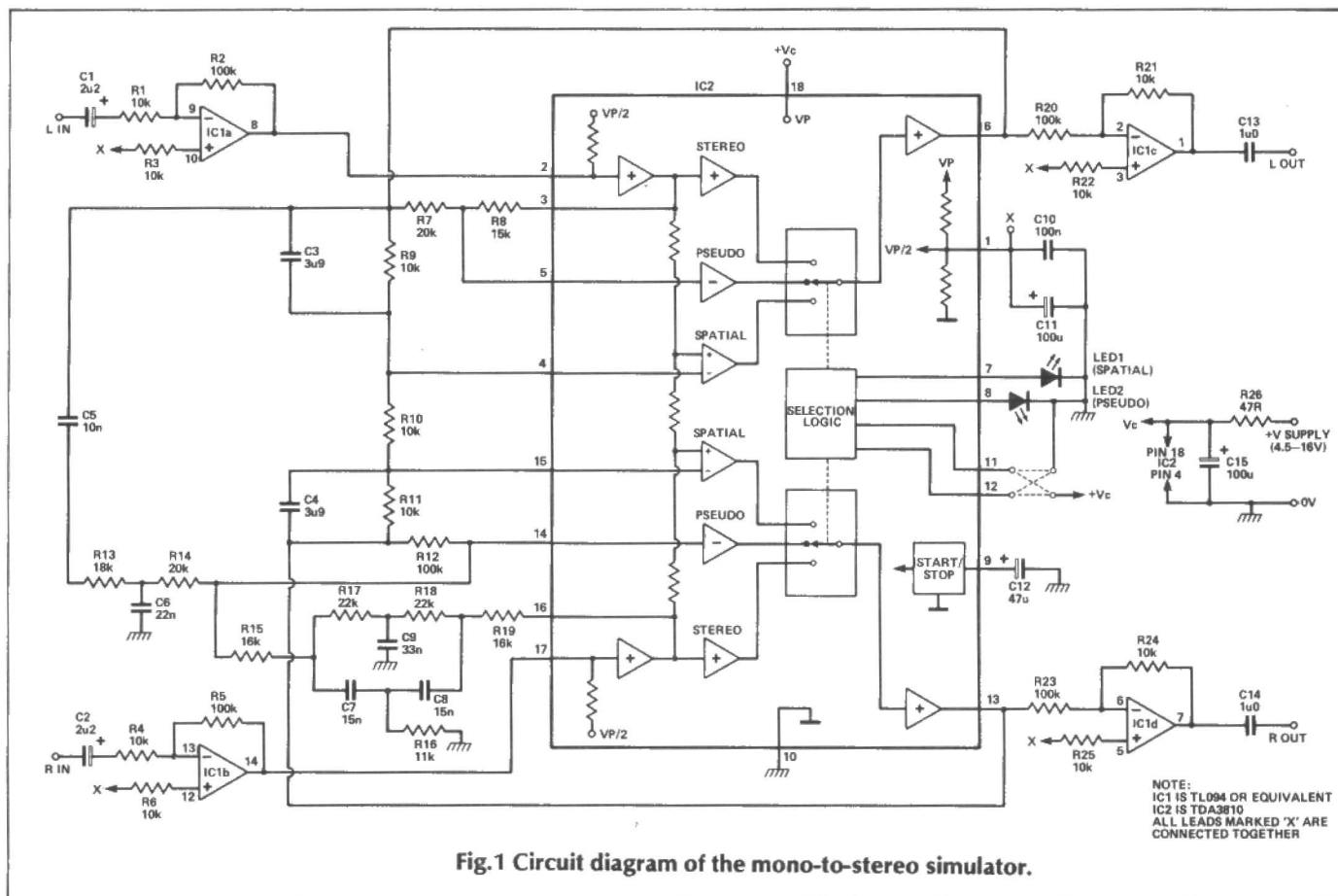


Fig.1 Circuit diagram of the mono-to-stereo simulator.

a low supply voltage (around 7 mA for 5V). Obviously, supply current with the LEDs depends on what LEDs you use.

If a relatively 'clean' supply is available, R26 and C17 may be omitted. This may be particularly of value when lower supply voltages are used, as the voltage drop across R26 may be significant.

The actual mode that the circuit is in is selected by the voltages applied to pins 11 and 12 of IC2 according to Table 1. Pins 11 and 12 could either be permanently connected to the appropriate voltages, or could be attached via a two pole, three way mode selection switch - one vital point, the switch must be break before make, otherwise it will momentarily short the positive supply to ground when it is moved.

Sensible values of capacitors C13 and C14 depend on the input impedance of the circuit being fed by the unit. The outputs of IC1c and d will be at around half the supply voltage, so if you have to use electrolytic capacitors check the voltage at the input point to see which way round the capacitors should go. Also, check the input DC voltage, as it may be necessary to reverse the input capacitors.

## HOW IT WORKS

In the stereo mode, operation is quite straightforward, as all the TDA3810 does is act as a buffer. The op amps IC1a and b are configured as  $\times 10$  amplifiers, for reasons that will be discussed later, and IC1c and d are  $\div 10$  amplifiers. So the net result is no change.

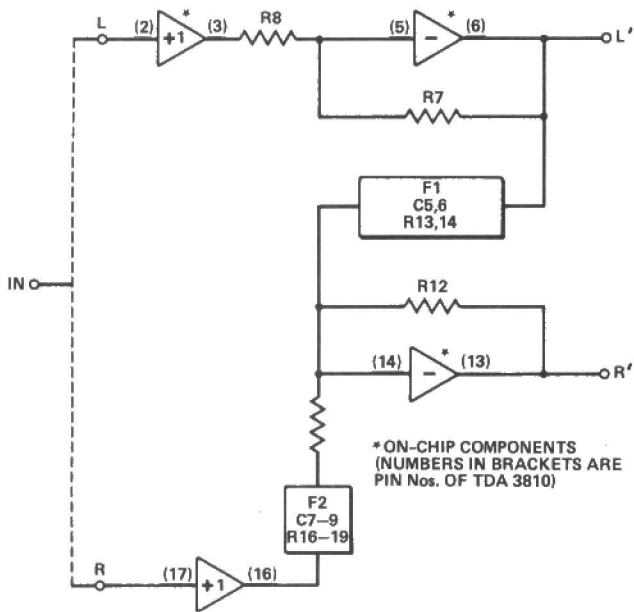
In the pseudo-stereo mode, IC1a - d act as before. However, IC2 is configured somewhat differently by its internal switches. The two filters, F1 and F2 are brought into circuit. Basically, the signal applied to the L input goes through to the L output with a small amplification and inversion. However, some of the inverted L input is passed to the input of the inverting amplifier in the R chain, via low-pass filter F1. This is combined with some of the non-inverted input fed in via the R terminal, which is passed through notch filter F2. Analysing what's going on in either F1 or F2 is difficult (particularly, in F2), and after several pages of algebra, we were little the wiser, so we cheated and used the values given in the manufacturer's data sheet! Let it suffice to say that the R channel has a different phase to the L channel as well

as a different frequency response, and that response varies with frequency.

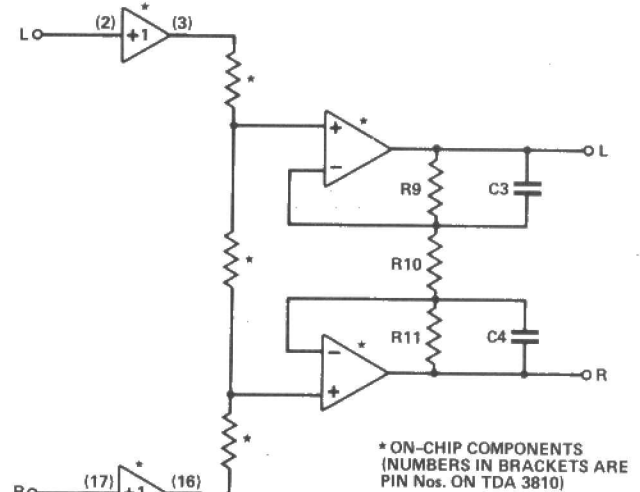
Finally, in spatial stereo mode, the configuration is as shown in Fig. 3. The input signals are buffered then slightly intermixed by the resistors connected between the  $\div 10$  buffers' outputs. The signals are passed to the op-amps which invert them. These op-amps are configured so as to produce anti-phase cross-talk, ie the right output contains 50% of the left input, but inverted. At higher frequencies, capacitors C3 and C4 reduce the cross-talk.

Op-amps IC1a and b increase the input signal level to 2V RMS, which assumes a 200mV RMS input signal to the whole unit - probably more common than 2V! 2V is the recommended minimum input voltage to the TDA3810 with a 12V supply; obviously, if the supply voltage is significantly lower than this, then the input signal level to IC2 should be decreased to allow sufficient operating headroom for it and for IC1a and b. This will be detrimental to the noise performance. Obviously, the gains of IC1a and b will have to be adjusted accordingly, as will the gains of IC1c and d.

## PROJECT: Stereo Simulator



**Fig.2 Block diagram of the circuit in pseudo-stereo mode.**



**Fig.3 Block diagram of the circuit in spatial stereo mode.**

## Construction

The first move should be to insert the IC sockets, making sure that you get them the right way round. This makes it easier to locate the positions of all the other components. Next insert and solder the resistors, followed by the capacitors, and then the LEDs. Finally, before inserting the ICs, check your work carefully and, in particular, look for solder bridges.

Now pick your insertion point in the main system that you're adding the unit to. The best point would be before the volume control, if the signal here is of a suitable level. In this way, the unit receives a more-or-less constant input signal level which makes for optimum signal-to-noise ratio.

The supply requirements of the circuit have already been mentioned. With a standard split supply circuit, it will probably be sufficient to feed the circuit from just the +ve supply and the 0V-

the current consumption requirements of the circuit are modest and should not cause any problems.

## BUYLINES

No special problems should occur here. The TDA3810 (as well as the more common TL094) can be purchased from Technomatic. Of the other components, the only trouble you may have is with the 3n9 capacitors for C3 and 4. Not many capacitor types are made with E12 series values nowadays, the E6 series being much more prevalent. However, polystyrene still seem to be available in E12 values, and this can be used here. The main problem with polystyrene capacitors is their size, but this has been allowed for on the PCB (in the main, polycarbonates have been specified for their relatively small size, not for any other reason; so long as the tolerance is 10% or better, any type should do, as this circuit does not have super-fi pretensions!).

## PARTS LIST

**RESISTORS (all 1/4 W 5%)**

R1,3,4,6,9-11,21, 22,24,25	10k (11 off)
R2,5,12,20,23	100k (5 off)
R7,14	20k
R8	15k
R13	18k
R15,19	16k (15k+ 1k)
R16	11k (22k//22k)
R17,18	22k

**CAPACITORS** (polycarbonate unless stated)

C1,2	2μ2 16V electrolytic
C3,4	3n9
C5	10n
C6	22n
C7,8	15n
C9	33n
C10	100n ceramic
C11	100μ10V electrolytic
C12	47μ 16V electrolytic
C13,14	1μ
C15	100μ 16V electrolytic

## SEMICONDUCTORS

IC1	TL094
IC2	TDA3810
LED1,2	LEDs to choice

## MISCELLANEOUS

PCB, wire, pins for off-board connections, switch if required (2-pole, 3-way, break before make).

MODE	CONTROL INPUT STATE		LED SPATIAL PIN 7	LED PSEUDO PIN 8
	PIN 11	PIN 12		
MONO PSEUDO—STEREO	HIGH	LOW	off	on
SPATIAL STEREO	HIGH	HIGH	on	off
STEREO	LOW	X	off	off

LOW = 0 to 0.8V (the less positive voltage)

HIGH = 2V to  $V_p$  (the more positive voltage)

X = don't care

**Table 1 Mode-switching logic.**



# ETI PCB SERVICE

In order to ensure that you get the correct board, you must quote the reference code when ordering. The code can also be used to identify the year and month in which a particular project appeared: the first two numbers are the year, the third and fourth are the month and the number after the hyphen indicates the particular project.

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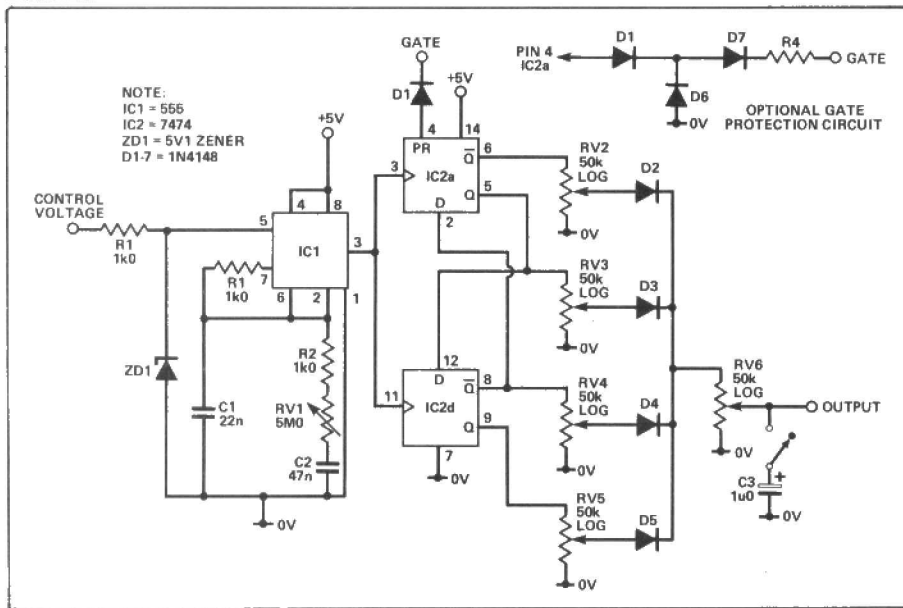
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# TECH TIPS

## Walking-ring Sequencer

S. P. Giles  
London



This simple circuit is quite useful for generating a number of functions. It can be used for trilling, vibrato or higher frequency modulation. It will also provide voltages for note sequences, gating, controlling filters, VCA's or any voltage controlled module.

A 555 timer is used as a simple voltage controlled clock with the five megohm potentiometer determining sequence speed along with the voltage at the control voltage input. This input will vary the speed with a positive voltage applied. This function is non-linear, has a 3:1 range and increases speed as the voltage decreases. With the component values shown (5M and 22n) the range is 2Hz to 7KHz. Larger values of CR will result in slower rates, and small values, faster ones.

A 7474 flip-flop is wired as a walking ring counter. The outputs overlap, so the final output is apparent as four steps. Moving one

## FET Grid-dip Oscillator

G. G. Mellor  
Macclesfield

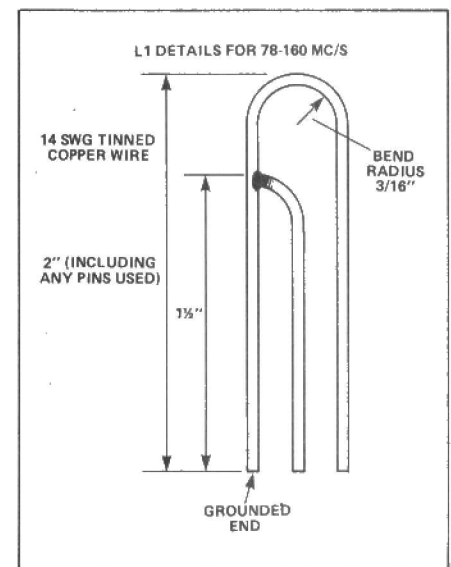
A relatively up to date version of the well known triode valve grid-dip oscillator can be constructed very simply and cheaply by replacing the RF triode by a FET such as the 2N3819, the BF245A or preferably, MPF106 in the trusty Hartley circuit. Although the physics of a triode and a FET are obviously different, they seem to operate in a similar fashion.

A non-mathematical explanation of the oscillation assumes an alternating RF potential on the source of Q1 which, due to the auto-transformer action of L1, gets amplified without any phase change (to make good any circuit losses). This voltage is fed to the gate of Q1. Since we are using Q1 in source follower mode, FET action maintains the amplitude of the alternating RF we first assumed. The tank circuit, L1 and C1, will provide the initial RF we require for this explanation on power-up.

The GDO must be calibrated and this can be done in one of (at least) two ways:

- Listen for the GDO frequency on a good communications receiver and, using spot frequencies, calibrate the C1 scale.
- Measure the GDO frequency with meter using a high impedance probe on the source of Q1.

Using the GDO is simple, the appropriate coil for L1 is plugged in and the GDO switched on. L1 (which is mounted on a 3 pin DIN plug external to the circuit) is brought in the vicinity of the tuned circuit under test (TCUT). C1 is adjusted for a local minimum in the



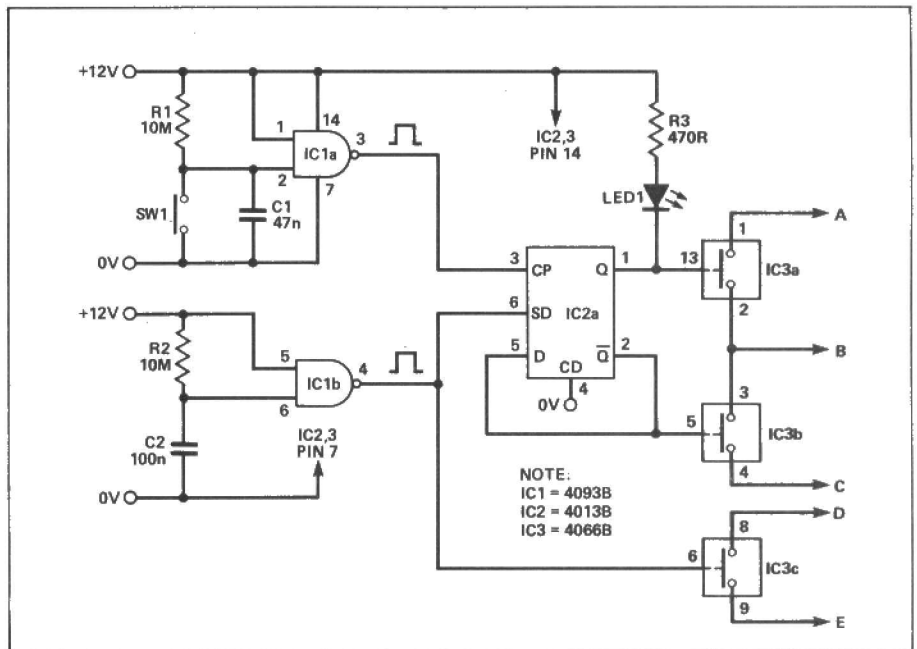
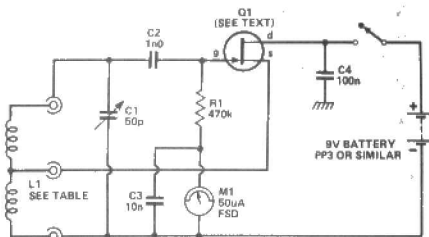
Coil	Frequency Range (MHz)	Number Of Turns	Tap	Wire Gauge (SWG)	Number of Turns Per Inch	Coil Diameter
A	1.6-3.5	139	32	36ENA	Close Wound	3/4"
B	3.45-7.8	40	12	36ENA	Close Wound	3/4"
C	7.6-17.5	40	14	24Tinned	32	1/2"
D	17.2-40	15	5	20Tinned	16	1/2"
E	37-85	4	1 1/2	20Tinned	16	1/2"
F	78-160	See Diagram				

of the four level controls moves the whole sequence. These should be adjusted for preferred operation. The primary disadvantage here is that individual notes are difficult to tune accurately so the sequence should be run fairly fast in order to minimise note inaccuracies when controlling a VCO.

The sequencer can be turned off at the gate input with a ground. No connection, or a positive voltage will allow the circuit to operate. This input is protected from normal synthesiser positive voltages, but negative voltages should not be applied unless you use the optional gate protection circuit. The 50K pot on the output controls the level from 0 to 3.5 volts. The  $1\mu\text{F}$  capacitor and switch are used to provide a slide function.

Note the power supply is 5 volts and must be regulated. Higher voltages may destroy the 7474 IC. If 5 volts is not available, use any 5 volt voltage regulator to step down a higher voltage.

meter reading and the frequency read off the scale. This "dip" in the reading occurs because some of the RF feedback in the GDO is absorbed by the TCUT consequently making the natural potential on the gate of Q1 less negative. It should be noted that loose coupling to the TCUT is essential to avoid the GDO frequency being "pulled" away from the value indicated on the scale. A dip can also occur when the GDO frequency is an integral sub-multiple of the TCUT frequency. However, practice in using the GDO will soon remedy this, and in any case there is no excuse for being a factor of 2, 3 or 4 out of the waveband you are supposed to be working in!



## Push-button Operated Change-over

D. Wells

Newport Pagnell

The circuit shown was developed during the design of a DC controlled pre-amplifier. Using momentary contact switches allowed standardisation of all front panel switches. As well as giving a single or double pole change over switch the circuit ensures that the power up state of the switches is always the same. In the author's application only DC control voltages were being switched so the limitations of the 4066 switches at audio frequencies were unimportant; other applications may need to take account of these.

IC1a goes high when SW1 is pressed, R1 and C1 provide a debounce function. The outputs of IC2a change state on the positive edge of IC1a output. As the two outputs of IC2a are complementary and are connected to the control inputs of two switches in IC3, a change over switch is achieved by commoning the outputs of the two switches. R3 and LED1 are optional and form a visual indication of switch status.

IC1b provides a short high pulse at its output immediately after power up. The values of R2 and C2 ensure that this pulse is longer than

the pulse from IC1a. The high from IC1b is connected to the set input of IC2a and causes the power up state to always be:

point A connected to point B and point B to C open circuit.

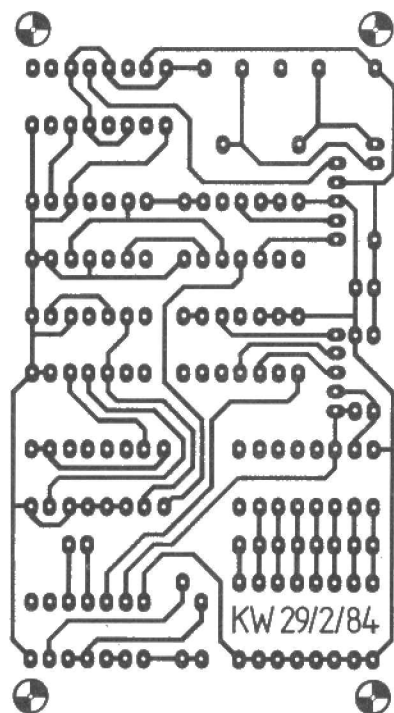
As it stands the circuit only uses half the gates in all three IC's. One possible use for these spare gates is shown in the diagram. The positive pulse from IC1b is fed to one of the spare switches in IC3. This switch was connected in parallel with one of the source select inputs thus ensuring that the same source was always selected at power up (the source switches were latched by the audio switching IC used). Other functions that could be implemented include: two single pole single throw switches; another single pole change over switch; a double pole single throw switch.

Could G. M. Heath get in touch with us over his contribution to Tech Tips and would all future contributors help us by marking their name and address on each sheet of their submission. Thanks.

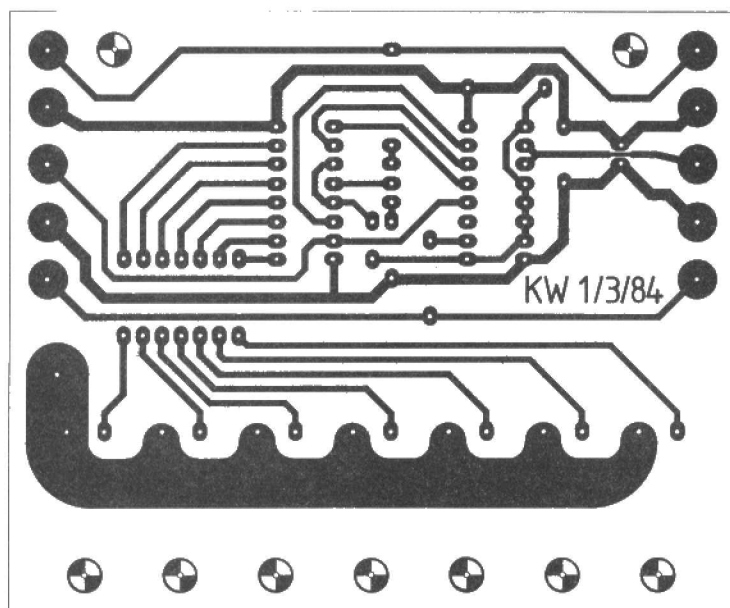
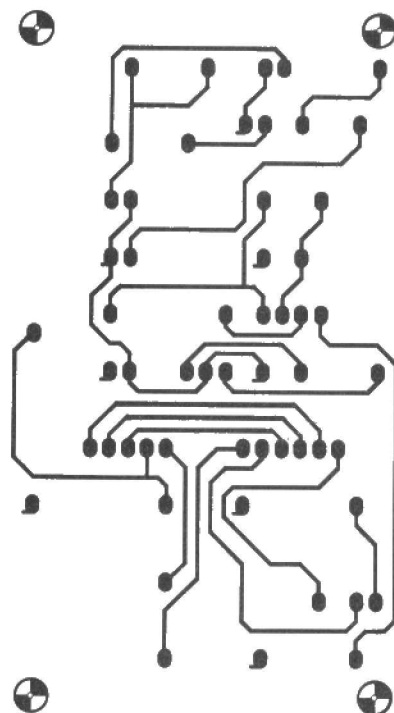
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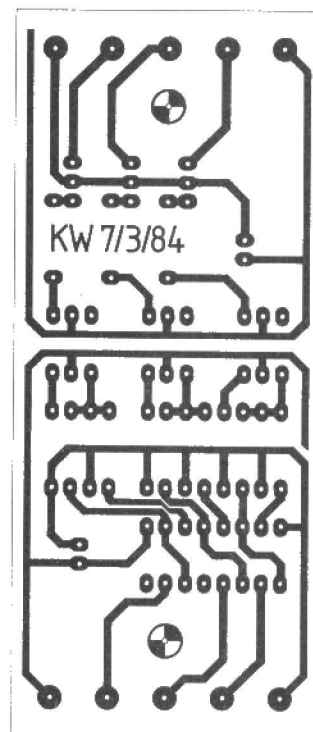
# PCB FOIL PATTERNS



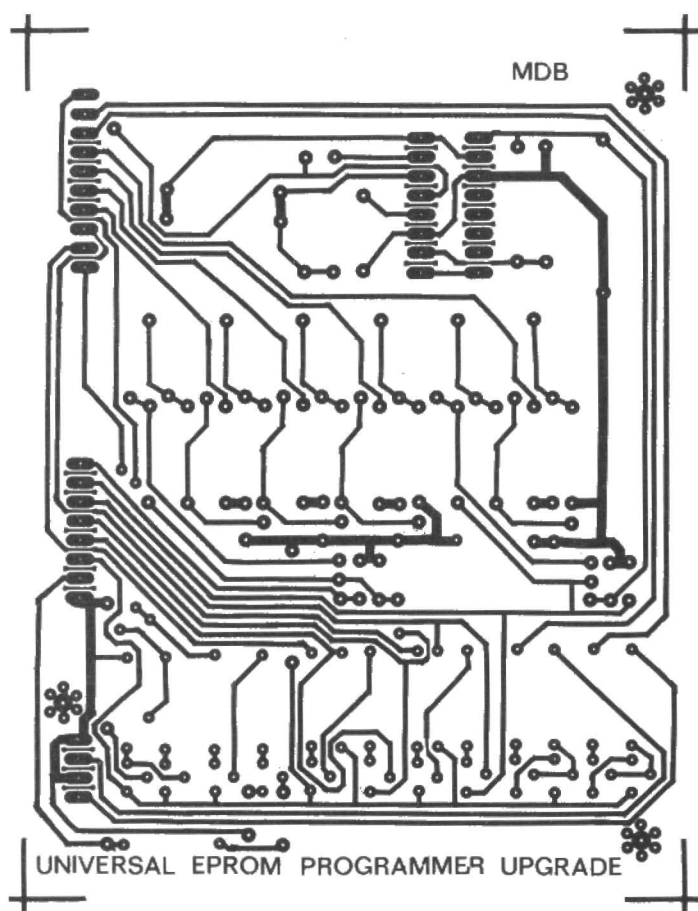
The top and bottom patterns for the scoreboard controller module.



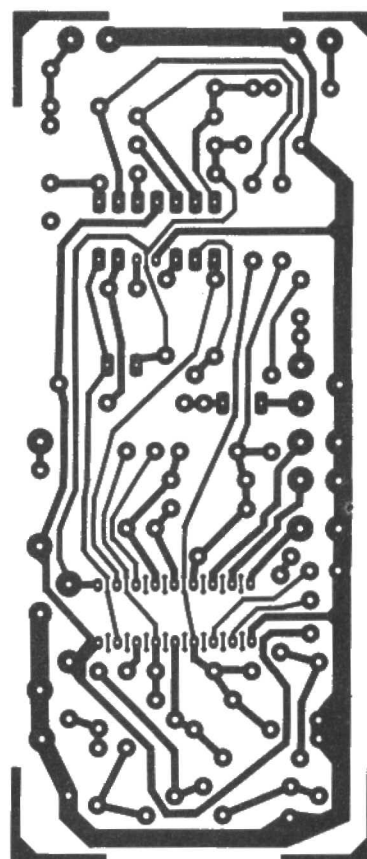
The digit driver board pattern for the scoreboard.



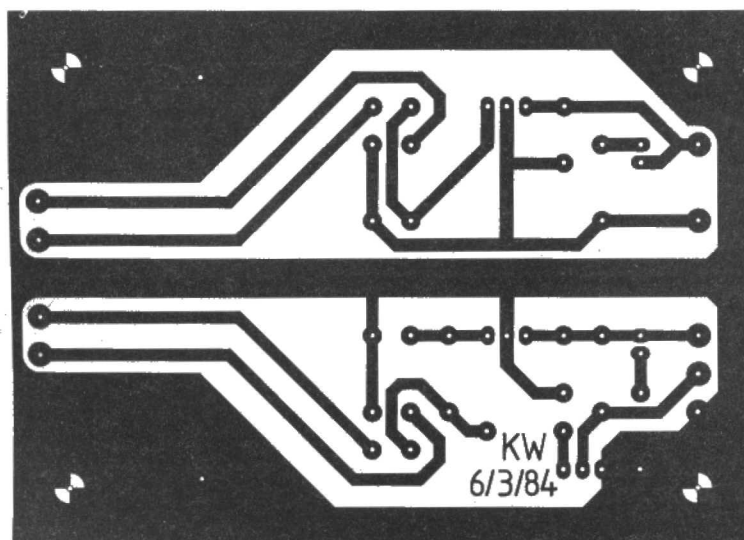
The pattern for the scoreboard opto-isolator module.



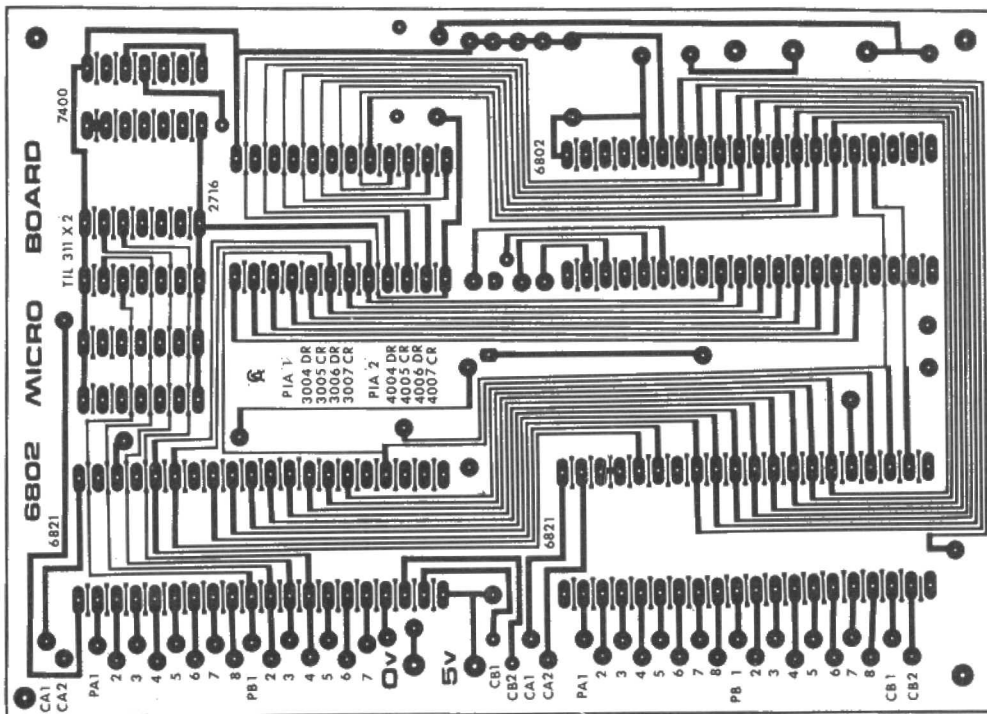
The EPROM Programmer upgrade board foil pattern.



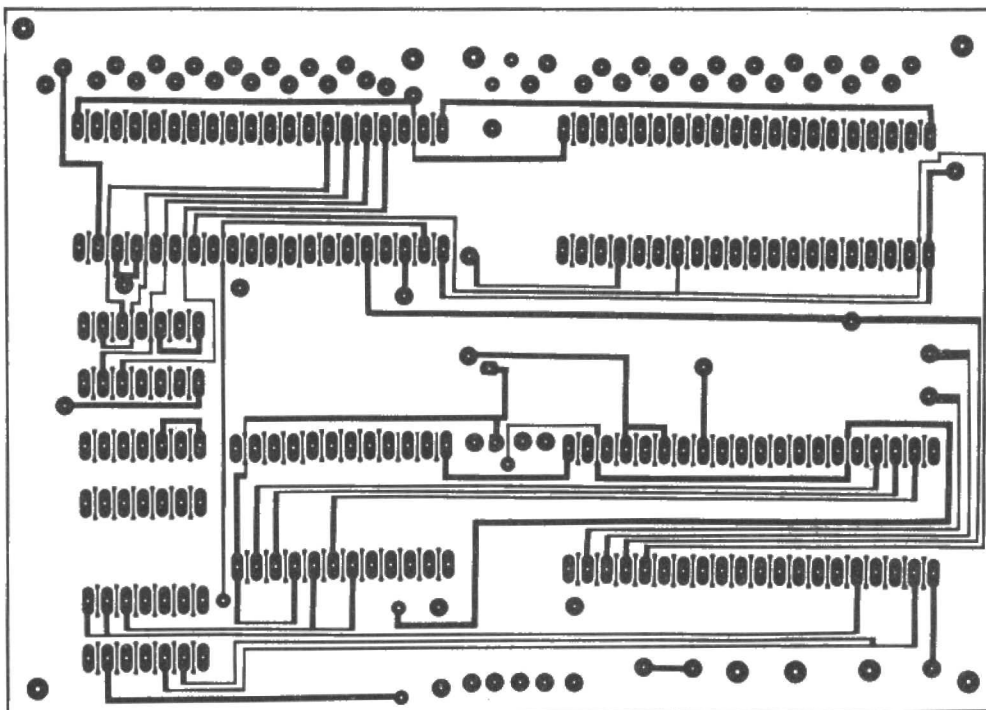
The mono-to-stereo simulator foil pattern.



The power supply board pattern for the scoreboard.



The top and bottom patterns for the 6802 Evaluation Board.





## OPEN CHANNEL

### Keep it human

When electronic communications systems were in their infancy, it seemed that the existing news communicators - newspapers - were in for a hard time. Pundits (then, and some even now) predicted the rise of the electronic newspaper and demise of the real McCoy. Well, the technology of the electronic newspaper is now with us, but it's being given a run for its money - after all, who on earth wants to sit in front of a computer display: CRT, LCD or other, to read the news when you could have a real, live newspaper folded on your lap.

The Financial Times will be the first UK publication to make use of SatStream North America and it obviously hopes to eliminate freighting costs, as well as being able to produce the paper in North America, hours earlier than previously possible.

A single satellite link is to be

used between the FT's head office at Bracken House in the City of London and the printer in New Jersey State, USA. Facsimile pages will be digitally transmitted from Bracken House to the printer at data rates up to 128 Kbits per second, via BTI's earth terminal, sited at Ealing. Confirmation of page reception will be provided by a low-data rate return path using BTI's KiloStream service.

The point I'm making is that, yes, electronic services can be super fast, super efficient, and just plain super, but they can also de-humanise a customer service, so much so that the customer will choose not to use it. The example I've used here shows that electronic services can be used to great advantage in the planning, preparation and production of a newspaper, but in the end the human consumer must be catered for. Paper newspapers do this, electronic newspapers don't. The principle is not restricted to newspapers, and planners of electronic services shouldn't forget it. It's for yoo-hoo

This month sees the planned start of British Rail's new service for commuting business - people: telephone links on-board

trains. The first stage will cover the London/Manchester and London/Liverpool lines, and goes into service with a single telephone in each first class executive Pullman carriage. BR plans to expand this rapidly (hopefully to second class, too - some of us fee-paying, ordinary-mortal commuters know what a 'phone is, you know!) and foresees a high usage of electronic mail via portable terminals. In effect, commuters can use the train as a mobile office. Presumably, BR feels that its

commuters should get some more work done and stop wasting time reading humanised newspapers.

Keith Brindley

Open Channel welcomes letters and information on products and events to do with telecommunications. Please address correspondence to 'Open Channel', ETI, ASP Ltd., 1 Golden Square, London W1R 3AB.

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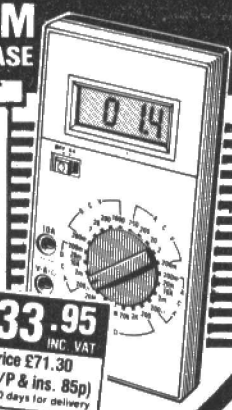
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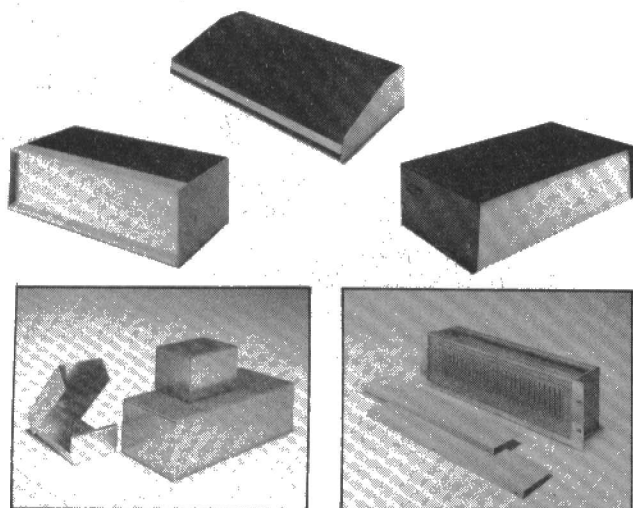


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## SCRATCH PAD

by Flea-Byte

Steve Wozniak is one of the legends of the electronics world. While still hardly more than a teenager, he and his friend Steven Jobs built a smallish, microprocessor-based device in a garage in California. This was in the mid-seventies and, when they started to sell similar devices through their local electronic parts supplier, they caused quite a stir. They began manufacturing the device on uncased PCBs and gave it a name - the Apple computer. By the early eighties, Jobs and Wozniak were reckoned to have personal fortunes well in excess of \$10m each. But, while Jobs went on to lead the Apple Computer Co. to greater and greater things, Wozniak quit in 1983, taking his money with him. He went into rock promotion, lost a couple of million, and signed up for a degree course in computer engineering - as a student. A couple of years later, the mercurial Wozniak applied for a job... as an engineer working at Apple Computer. Despite his millions, he was accepted on the 'shop floor' and helped develop products for the Apple IIe and IIc. Then,

early this year, he quit again saying he was fed-up with working on computers. Instead, says Wozniak, he is starting a company called MBF Corporation - which stands for 'My Best Friend'. MBF's first product will be a controller for home video systems. 'It is not,' says Wozniak defiantly, 'a computer or a peripheral'.

\*\*\*

Interesting to note the results of the latest poll in 'New Scientist'. Asked - among other things - to name three famous scientists, members of the Great British Public plumped overwhelmingly for 'Don't Know'. Don't Know is, of course, dead-like most of the other scientists who appeared in the poll results. He or she is, however, thought to be responsible for inventing the wheel, viruses, sexual reproduction and the Third Law of Thermodynamics. Readers will be pleased to learn that, according to the poll results, the world's greatest living scientist (in fact, the world's only living scientist) is Sir Clive Sinclair, inventor of the tricycle.

\*\*\*

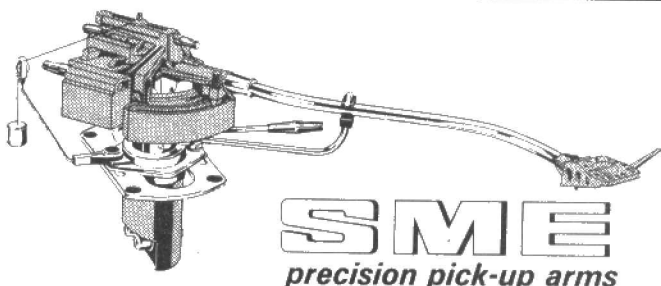
The latest news from Silicon Valley suggests that maybe it should be renamed. Cocaine Valley, perhaps? Or Amphetamine Alley? Evidently, the use of 'uppers' like cocaine and amphetamines has become so widespread among the elec-

tronics community that many companies have had to consider screening prospective employees for signs of drug use. IBM has actually introduced a screening policy. (Perhaps the company should now be known as Big Blues!) Practically every other big name in the Valley has fought shy of such a move. They are doubtless aware of the fact that hardly anybody could stand the pace of developing breakthrough technologies every other day without recourse to stimulants. Also Intel, Nat Semi, Apple and the rest must know that there are more jobs around in their part of the world than qualified people to fill them. Indeed, with an average salary of \$28,000 which is already 75% higher than the US average, perhaps it's time for the high technology companies of Silicon Valley to start offering inducements in non-financial forms to

woo new talent. Could the sunrise industries become the snowfall industries?

\*\*\*

While the robot population of Britain rose by 33% last year to a total of 2,623 (not including the occupants of the House of Commons or the cast of 'Crossroads'), the country is still only sixth in the league behind France, Italy, West Germany (with 6,600 robots), the US (13,000) and Japan (64,600). Of course, it's common knowledge that the Japanese have a different system for counting robots. For example, they claim to have developed a device controlled by 67 16 and 8-bit micros which can read music, listen to instructions, talk and play keyboards. In Britain, this would be known as Richard Clayderman.



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- Where a project has apparently been constructed correctly but does not work, we will need a description of its behaviour and some sensible test readings and drawings of oscillograms if appropriate. With a bit of luck, by taking these measurements you'll discover what's wrong yourself. Please do not send us any hardware (except as a gift!);

- Other than through our letters page, Read/Write, we will not reply to enquiries relating to other types of article in ETI. We may make some exceptions where the enquiry is very straightforward or where it is important to electronics as a whole;

- We receive a large number of letters asking if we have published projects for particular items of equipment. Whilst some of these can be answered simply and quickly, others would seem to demand the compiling of a long and detailed list of past projects. To help both you and us, we have made a full index of past ETI projects and features available (see under Backnumbers, below) and we trust that, wherever possible, readers will refer to this before getting in touch with us.

- We will not reply to queries that are not accompanied by a stamped addressed envelope (or international reply coupon). We are not able to answer queries over the telephone. We try to answer promptly, but we receive so many enquiries that this cannot be guaranteed.

- Be brief and to the point in your enquiries. Much as we enjoy reading your opinions on world affairs, the state of the electronics industry, and so on, it doesn't help our already overloaded enquiries service to have to plough through several pages to find exactly what information you want.

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We are always looking for new contributors to the magazine, and we pay a competitive page rate. If you have built a project or you would like to write a feature on a topic that would interest ETI readers, let us have a description of your proposal, and we'll get back to you to say whether or not we're interested and give you all the boring details. (Don't forget to give us your telephone number).

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## OOPS!

Corrections to projects are listed below and normally appear for several months. Large corrections are published just once, after which a note will be inserted to say that a correction exists and that copies can be obtained by sending in an SAE.

### EPROM Card (June 1984)

On the circuit diagram, Q2 base is shown connected to +25V, but should be connected to +5V. Q3 should not be connected to 0V, but only to point a. The capacitor connected between +25V and 0V is C5 and should be 2µF 35V tantalum bead. Switch connected across C4 is SW1 on overlay. Increase R8 to 2k7 if using suggested PSU. (R8 OK for 24V).

### Spectrum Joystick Interface (June 1984)

The PCB and the circuit diagram do not agree; the circuit diagram is correct, and all PCBs sent out by the PCB service should have been amended. IC3 is 74LS241, as correctly stated in the parts list but incorrectly given in the footnote to the circuit diagram.

### CMOS Tester (August 1984)

C3 and C2 are reversed on the overlay: C3 is the electrolytic and C2 the polyester. R33 is 100K, not 1M as given in the parts list, and RV1 is a 1M horizontal skeleton preset. R1-16 are two, eight-resistor SIL packages, the component labelled C14 on the overlay is SK1, and the connections to D2 shown in Fig. 3 are reversed. On the circuit diagram, the eight lines connecting SW9-16 to the inverters are shown in reverse sequence. Some of the inverters have been given the wrong designations; the correct sequence, reading down from the top, is: IC1f, IC2a, IC2b, IC1e, IC1d, IC1c, IC1b, IC1a, IC2c, IC2d, IC2e, IC3d, IC3a, IC3b, IC3c, IC2f. Finally, the pin numbers are missing from ICs 3e and f; the input of IC3e is pin 11 and its output pin 12, and the input of IC3f is pin 14 and its output is pin 15. The PCB is correct in all respects.

### Sharp Joystick Interface (August 1984)

Some of the inverter pins are incorrectly labelled on the circuit diagram. Pins 11 and 10 are shown reversed on IC1b, pins 9 and 8 are shown reversed on IC1c, and the output of IC4d is pin 10, not pin 20. Note that a number of the inverters have been incorrectly shown as non-inverting buffers.

### AM/FM Radio (November 1984)

In Fig. 2, the oscillator and IF sections should be shown connected to ground; the PCB is correct. In Fig. 4, C31 should be 10n to give the 75us deemphasis shown in Fig. 3, but 4n7 has been found to give a brighter midrange. R38 in Fig. 5 should, of course, be 820k rather than 280k and it and the bottom end of C38, C44 etc should be shown connected to ground. In the construction section on page 25, four pieces of 8mm plywood are mentioned but in fact only three are needed — the fourth side is the front panel. See also the note in December News Digest regarding availability of the inductors.

### Digital Control Port (November 1984)

The second sentence in the "Testing" section on page 30 should include the words 'without any ICs in place'. In the second paragraph of that section, the check for +5V should be made on pin 3 of IC101, not IC1. At the bottom of the first column on page 31, the last sentence should finish with B3 = 0.

### Video Vandal (November 1984)

In Fig. 8 on page 54, R16 and R17 should be shown connected to the base of Q4, and C12 and SW2 should be in the D output line rather than the OV line. It may also be beneficial to add a diode across R3 with its anode connected to the slider of RV1. In Fig. 10, R52 and LED2 are shown connected across the +12V supply but it is better to place them across the -12V supply so as to even-up the dissipation in the ICs.

### VCDO (March 1985)

RV2 should be 10k (right in parts list, wrong on circuit diagram).



## REVIEW

### Digital Lab

#### Computer software

Associate Services Ltd.

23 Chesham Street

London SW1X 8NQ

price: £29.95

For some years now, sophisticated circuit design and analysis software has been available for expensive minicomputers and mainframes. One of the most interesting developments in the micro field in recent months - interesting, that is, for those involved in electronics - is the introduction of cheap packages for circuit design and analysis on home computers.

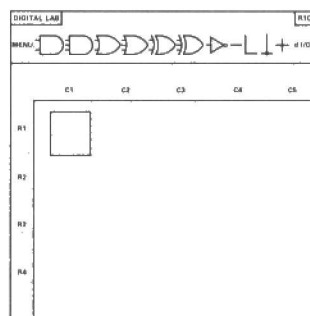
Digital circuit design and testing would seem to be the obvious direction for software developers in this area to take. So it's surprising to find that the best packages (and there are only a handful of them) are actually devoted to modelling and analysing linear circuits.

Apart from Sinclair Research's 'Make-A-Chip' package for the

Spectrum, which pretends to be no more than educational, there has been nothing to my knowledge tackling the problems of either combinatorial or sequential logic design. Until now, that is.

'Digital Lab' is a package produced by Associated Services (London) Ltd., of 23 Chesham Street, London SW1X 8NQ, for the Commodore 64. The disk-based software comes with a 60-page manual and costs around £30. In all fairness, Associated Services aim the program at 'pupils and students who would like to extend their practical approach to designing and constructing logic circuits' - although they do claim that the program can be used to help actual circuit construction.

I must confess that I assumed 'Digital Lab' would turn out to be a real designer's tool before actually trying it out. In that respect, I was disappointed. The package allows you to link together as many gates as you can fit into a 99 row by 99 column matrix (windowed on the screen as a five by five matrix), but there are no NAND, NOR or EXNOR gates available - these having to be built-up from ANDs, ORs and NOTs - and the



#### The initial screen of Digital Lab

maximum number of inputs to any one gate is only three. Neither does the package support sequential logic - except by allowing you to observe the action of single RS, D-type and JK bistables.

With these restrictions, 'Digital Lab' can only substantiate a claim to being an educational tool. And, despite one or two quirks, as an educational tool it works well. The quirks are largely to do with the style in which the software has been programmed. The author could have made one or two simple modifications to improve the package - for example, the

ability to hold the 'input-output screen' (in which the circuit you have designed is assigned input and output names) and alter the design would have been useful. As it stands, if you want to alter your circuit in any way, input-output lines have to be re-assigned from the start. This is quite a tedious procedure.

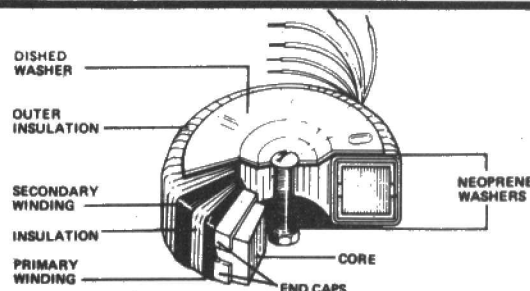
I would expect to see more packages like this being produced in the future. No doubt, their authors will learn from this one and make what improvements they can. At the moment, 'Digital Lab' has the edge because the competition is practically non-existent. Its own merits are also clear. It is a powerful, value-for-money aid in learning about combinatorial logic. It is not really a designer's tool and, even as a learning aid, it should be used together with a good book on logic circuits. Its one virtue for the professional or advanced amateur is that the program takes the tedium out of calculating truth-tables for complex gate arrangements. For this reason alone, Commodore-64 owners involved in logic design may well have reason to be very grateful to Associated Services.

Gary Herman

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0x014	18+18	0.42	2x016	25+25	1.00 <td>4x016</td> <td>25+25</td> <td>2.40<th>6x018</th><th>35+35</th><th>3.21</th><th>8x042</th><th>55+55</th><th>4.54</th></td>	4x016	25+25	2.40 <th>6x018</th> <th>35+35</th> <th>3.21</th> <th>8x042</th> <th>55+55</th> <th>4.54</th>	6x018	35+35	3.21	8x042	55+55	4.54
0x015	22+22	0.34	2x017	30+30	0.83 <td>4x017</td> <td>30+30</td> <td>2.00<th>6x026</th><th>40+40</th><th>2.81</th><th>8x028</th><th>110</th><th>4.54</th></td>	4x017	30+30	2.00 <th>6x026</th> <th>40+40</th> <th>2.81</th> <th>8x028</th> <th>110</th> <th>4.54</th>	6x026	40+40	2.81	8x028	110	4.54
0x016	25+25	0.30	2x018	110	0.45 <td>4x018</td> <td>35+35</td> <td>2.25<th>6x025</th><th>45+45</th><th>2.50</th><th>8x029</th><th>220</th></td> <th>2.27</th>	4x018	35+35	2.25 <th>6x025</th> <th>45+45</th> <th>2.50</th> <th>8x029</th> <th>220</th>	6x025	45+45	2.50	8x029	220	2.27
0x017	30+30	0.25	2x029	220	0.22 <td>4x028</td> <td>50+50</td> <td>1.10<th>6x033</th><th>50+50</th></td> <th>2.25</th> <th>8x030</th> <th>240</th>	4x028	50+50	1.10 <th>6x033</th> <th>50+50</th>	6x033	50+50	2.25	8x030	240	2.08
(encased in ABS plastic)			2x030	240	0.20 <td>4x029</td> <td>220</td> <td>0.54<th>6x028</th><th>110</th></td> <th>2.04</th> <td colspan="3"></td>	4x029	220	0.54 <th>6x028</th> <th>110</th>	6x028	110	2.04			
						4x030	240	0.50 <th>6x029</th> <th>220</th>	6x029	220	1.02			
									6x030	240	0.93			
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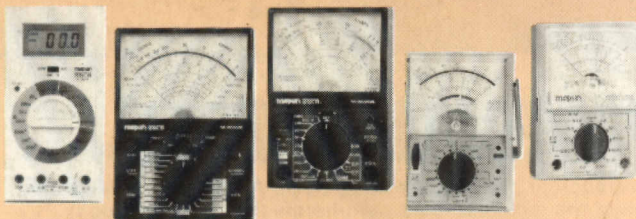
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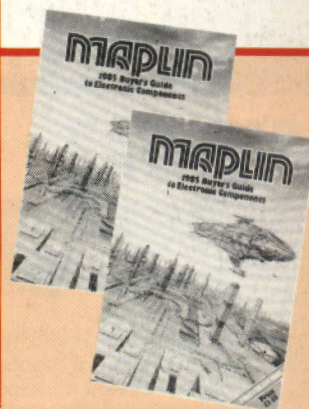
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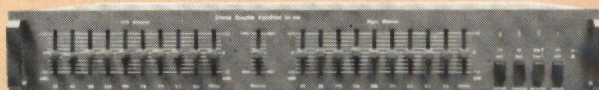
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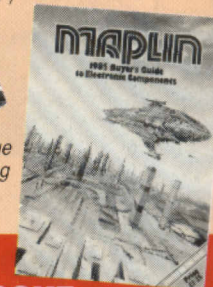
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